APPENDIX B3
ITS PROJECT SPECIAL PROVISIONS

I-405, SR520 to SR522 Stage 1 (Kirkland Stage 1)

Final Package Review – 15%
January 25, 2005

INTERSTATE 405 Project Team
Congestion Relief & Bus Rapid Transit Projects

APPENDIX B3

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DEFINITIONS AND TERMS

Abbreviations

Associations and Miscellaneous

Section 1-01.2(1) is supplemented with the following:

bps	Bits Per Second of Serial Data
CAM	Camera
CCTV	Closed Circuit Television
CC	Camera Cabinet
CPU	Central Processing Unit
CWDM	Course Wave Division Mutiplex
dB	Decibel
dBm	Decibel referenced to 1 milliwatt
DS	Data Station
DS-1	Digital Signal Level 1 (1.544 Mbits/s)
DS-3	Digital Signal Level 3 (44.736 Mbits/s)
ES	Electronic Surveillance
EPROM	Electronically Programmable Read-Only Memory
FM	Frequency Modulation
HAR	Highway Advisory Radio
HARS	Highway Advisory Radio Sign
HART	Highway Advisory Radio Transmitter
ITS	Intelligent Transportation System
Kbps	Thousands of Bits Per Second of Serial Data
LASER	Light Amplification by Stimulated Emission of Radiation
LED	Light Emitting Diode
Mbps	Millions of Bits Per Second of Serial Data
MMFO	Multimode Fiber Optics
MUX	Multiplexer
nm	Nanometer (10-9 meter)
OC-1	Optical Carrier Level 1 (50.84 Mbits/s)
OC-12	Optical Carrier Level 12 (622.08 Mbits/s)
OFNR	Optical Fiber Nonconductive Riser
OSP	Outside Plant
OTDR	Optical Time Domain Reflectometer
PTZ	Pan, Tilt, Zoom (for camera control)
RGB	Red, Green, Blue video signals
RMU	Rack Mounting Unit (1.75 inches)
SC&DI	Surveillance, Control and Driver Information
SMFO	Singlemode fiber optics
SONET	Synchronous Optical Network
STS-1	Synchronous Transport Signal Level 1 (electrical 50.84 Mbits/s)
T1	See DS-1
T3	See DS-3
TC	Terminal Cabinet
TDM	Time Division Multiplex
TMS	Traffic Management System
TSMC	Traffic Systems Management Center
TWP	Twisted Wire Pair

UPS	Uninterruptable Power Supply
VMS	Variable Message Sign
WSTA	Weather Station
ZIF	Zero-Insertion Force

LIQUIDATED DAMAGES

Section 1-08.9 is supplemented with the following:

Unplanned disruptions to the Intelligent Transportation System (ITS) will result in impacts to the traveling public, increase fuel consumption, vehicle operating costs, pollution, and other inconveniences and harm far in excess of those resulting from delay of most projects.

Accordingly, the Design-Builder agrees:

1. To pay $250.00 liquidated damages per 15 minutes for each 15 minute period that the Design-Builder fails to restore the proper operation of an existing ITS element following an unplanned disruption as specified in the subsection **Existing System Disruption and Restoration** of the Special Provision **INTELLIGENT TRANSPORTATION SYSTEM (ITS)**.

2. To authorize WSDOT to deduct these liquidated damages from any money due or coming to the Design-Builder.

INTELLIGENT TRANSPORTATION SYSTEM (ITS)

Description

Section 8-20 and 9-29 are supplemented to include these ITS Project Special Provisions.

1. Directional Boring
2. Closed Circuit Television System
3. Communication Cables and Interfaces
4. Video, Voice & Data Distribution and Transmission System
5. Highway Advisory Radio System
6. Variable Message Sign

Materials

Conduit

Section 9-29.1 is supplemented with the following:

Directional Boring

Drilling fluid used for directional boring shall be an inert mixture of water and bentonite clay conforming to the drilling equipment manufacturer's recommendations.

Surface Mounting Conduit Attachment Components

Unistrut type channel supports and fastening hardware components shall be stainless steel. Conduit clamps shall be hot-dip, galvanized steel or stainless steel, and shall be one piece, two bolt units with lock washers. The clamps shall be attached to the unistrut type channel supports on both sides of the conduit with bolts and associated hardware. The minimum distance between adjacent clamps and between the clamp and the end of the unistrut type channel supports shall be one inch. Unistrut type channel supports shall be installed with stops, which prevent clamps from sliding out of the ends.

Junction Boxes

Section 9-29.2 is supplemented with the following:

NEMA Stainless Steel Junction Boxes

NEMA stainless steel junction boxes and cover screws shall conform to ASTM A 304. Junction boxes installed on exterior of structures shall have an external hinge. Junction boxes shall be labeled with the appropriate designation. See Standard Plans for traffic signal system and illumination system labeling. Communication system boxes shall be labeled in the same manner, with the exception that the label shall be COMM.

Polyethylene drain tubes for junction boxes mounted in structures shall be 3/8-inch diameter with a wall thickness of 0.062 inches and shall be rated for a 110 psi working pressure at 73° F.

Surface mounted junction boxes and junction boxes placed in cast in place structures shall be NEMA 4X.

Junction boxes installed in structures constructed by slip forming shall be NEMA 3X and shall be adjustable for depth, with depth adjustment bolts, which are accessible from the front face of the junction box with the lid installed.

Type 4, 5 and 6 Junction Boxes

Type 4, 5 and 6 junction boxes shall meet the following requirements:

Concrete shall have a minimum compressive strength of 4000 psi. The steel frame and lid shall be painted with a shop applied, inorganic zinc primer in accordance with Section 6-07.3.

Material shall conform to the following:

Concrete	Section 6-02
Reinforcing Steel	Section 9-07
Lid	ASTM A786 diamond plate rolled from plate Complying with ASTM A572, Grade 50 or ASTM A588, both with min. CVN toughness of 20 ft-lb at 40 F
Frame and Stiffener Plates	ASTM A572, Grade 50 or ASTM A588, both with min. CVN toughness of 20 ft-lb at 40F
Handle	ASTM A36 steel
Anchors (studs)	Section 9-06.15
Bolts, Nuts, Washers	ASTM F593 or A193, type 304 or 316

The lid stiffener plates shall bear on the frame. Mill so that there is full even contact, around the perimeter, between the bearing seat and lid stiffener plates, after fabrication of the frame and lid. The bearing seat and lid perimeter bar shall be free from loose mill scale, burrs, dirt and other foreign debris that would prevent solid seating. Bolts and nuts shall be liberally coated with anti-seize compound. Bolts shall be installed snug tight. The bearing seat and lid perimeter bar shall be machined to allow a minimum of 75% of the bearing areas to be seated with a tolerance of 0.0 to 0.005 inches measured with a feeler gage. The bearing area percentage will be measured for each side of the lid as it bears on the frame.

Type 4, 5 and 6 junction boxes and lids shall have a vertical load strength of 46,000 pounds without permanent deformation and 60,000 pounds without failure.

For each type of junction box (type 4, 5 and 6) to be installed, the Design-Builder shall provide a certified test report, prepared by an independent testing lab, which documents results of testing done by the independent testing lab for the manufacturer. The test report shall certify that the boxes meet or exceed the loading requirements and shall document the results of the load test listed below. The independent testing lab shall be approved by the State Materials Engineer and shall be located within the State of Washington. Representatives of the State Materials Lab shall witness the test and sign the test report. The Design-Builder shall give WSDOT 30 days notice prior to testing. Three copies of the test report shall be provided to WSDOT prior to acceptance.

Boxes shall be load tested to 46,000 pounds and then to 60,000 pounds. The test load shall be applied in both longitudinal and transverse orientations. At each interval the test box shall be inspected for lid deformation, failure of the lid/frame welds, vertical and horizontal displacement of the lid frame, cracks, and concrete spalling. The test load shall be applied uniformly through a 10 inch x 20 inch x 1 inch steel plate centered on the frame.

Junction boxes meeting the 46,000-pound requirement shall not exhibit any of the following deficiencies:

1. Permanent deformation of the lid or any impairment to the function of the lid.
2. Vertical or horizontal displacement of the lid frame.
3. Cracks wider than 0.012 inches that extend 12 inches or more.
4. Fracture or cracks passing through the entire thickness of the concrete.
5. Spalling of the concrete.

Junction boxes meeting the 60,000-pound requirement shall exhibit the following:

1. The lid is operational.
2. The lid is securely fastened.
3. The welds have not failed.
4. Permanent dishing or deformation of the lid is ¼ inch or less.
5. No buckling or collapse of the box.

Section 9-29 is supplemented with the following:

Transformers and Cabinets

The transformers to be furnished shall be indoor/outdoor dry type transformers.. The transformer coils, buss bar, and all connections shall be copper. Transformers, 7.5 kVA and larger shall be supplied with two full capacity taps, one at 5% and one at 10% below the normal full capacity.

Transformer cabinets furnished for this contract shall be pad mounted and fabricated in accordance with Section 9-29.25 except:

1. Cabinets shall be fabricated of 0.125 inches sheet aluminum, 5052 alloy, with mill finish, in accordance with Section 9-29.13(7)D, Item number 1. Painted or anodized aluminum is not allowed.

2. The nominal cabinet dimensions shall be 48 inches high, 24 inches wide and 18 inches deep.

3. Cabinet doors shall be two-hinged with neoprene gasket and provided with a three-point latch and two-position stop assembly with spring loaded construction core lock capable of accepting a Best Lock Company 6-pin CX series core. The Design-Builder shall supply green construction cores with two master keys and one core key per lock. The Design-Builder shall deliver the keys to WSDOT.

Section 8-20.2 is supplemented with the following:

For additional material requirements, see Sections 8-20.2 and 9-29 as modified in the **Materials** subsection of the Special Provision **ILLUMINATION, TRAFFIC SIGNAL SYSTEMS, AND ELECTRICAL**.

Construction Requirements

General

Section 8-20.3(1) is supplemented with the following:

Approval of Material
When submitting material lists for approval, the Design-Builder shall identify all revisions or changes to manufacturer names, component names, and model numbers listed in these Special Provisions. The Design-Builder shall also include a brief justification for the revision or change.

Approval of Material
When submitting material lists for approval, the Design-Builder shall identify all revisions or changes to manufacturer names, component names, and model numbers listed in these Special Provisions. The Design-Builder shall also include a brief justification for the revision or change.

Existing System Disruption and Restoration
The Design-Builder shall use every precaution to ensure that no contract work causes disruptions to the existing systems, except those disruptions that are planned and approved in advance, as defined herein.

Existing systems include, but are not limited to, the following:

A. All ITS field devices, such as ramp meter, data collection, and CCTV systems, within the project construction limits.

B. Fiber optic and TWP data and video communication systems on *** $$1$$ ***.

Planned Disruptions
Contract work may require disruptions to existing systems, circuits, and equipment. The Design-Builder shall schedule the work and predetermine the affected system(s), extent, start time, and duration of planned disruptions. Planned disruptions shall be scheduled for nights or weekends between the hours of 8 P.M. and 4 A.M. Failure of the Design-Builder to restore disrupted systems and equipment prior to 4 A.M. will constitute an unplanned disruption, and the "Restoration Procedure" below will apply.

Requirements
Twenty-one calendar days prior to planned disruptions of any existing system, circuit, or equipment, the Design-Builder shall submit to WSDOT for approval a written Disruption Request. Each Disruption Request shall

include the system(s) to be affected, the disruption start date and time, and the estimated duration required. The Design-Builder shall submit a separate, numbered Disruption Request for each planned disruption. Disruption Request approval or rejection will be returned to the Design-Builder in writing by WSDOT at least seven calendar days prior to the proposed start of the disruption. WSDOT may reject a requested time or duration and verbally recommend an alternate time or duration agreeable to both the Design-Builder and WSDOT.

Restoration Procedure
Any unplanned disruptions determined by WSDOT to be caused by the actions of the Design-Builder or the Design-Builder's representative(s) shall be corrected by the Design-Builder at no additional cost to WSDOT.

Upon the occurrence of an unplanned disruption and subsequent notification by WSDOT, the Design-Builder shall immediately stop all other ITS work in progress, in accordance with Section 1-08.6, and shall expend all efforts to restore the disrupted system(s) or correct the problem causing the disruption. The Design-Builder will not be granted an extension of time for delays caused by the repair of disrupted systems. Unplanned disruptions shall result in the assessment of liquidated damages in accordance with the subsection **Liquidated Damages** of the Special Provision

Prosecution and Progress

ITS System Order of Work
The Design-Builder shall submit for review and approval a proposal for accomplishing the ITS work to WSDOT along with a copy to:

Freeway Systems Engineer
15700 Dayton Avenue North
P.O. Box 330310
Seattle, WA 98133-9710

The proposal shall be approved before any ITS fieldwork begins. The proposal shall include a critical path for ITS construction which shows dates of disconnection, reconnection, and installation of the following ITS components as applicable to this contract:

1. Traffic Data Accumulation And Ramp Metering System
2. Closed Circuit Television System
3. Highway Advisory Radio System
4. Communication Conduit System
5. Communication Cable and Interfaces
6. Variable Message Sign
7. Video, Voice & Data Distribution and Transmission System

The critical path shall also indicate all roadway lane shifts or closures that will be in effect during ITS construction.

Removal and Delivery of Existing Electrical Equipment
Where identified in the Plans, the Design-Builder shall remove and deliver the existing devices to:

3700 9th Ave. S.
Seattle WA 98134
Attention: Jeri Rahm

(206) 764-4014

Five days written advance notice shall be given to both WSDOT and the electrical parts specialist at the address listed above. Delivery shall occur during the hours of 6:30 a.m. to 2:00 p.m. Monday through Friday. Material will not be accepted without the required advance notice.

Equipment damaged during removal or delivery shall be repaired or replaced to WSDOT's satisfaction at no cost to WSDOT.

Conduit

Section 8-20.3(5) is supplemented with the following:

Conduit installed at the following locations shall be Rigid Galvanized Steel:

Within railroad right of way unless otherwise specified in the contract.

All runs within slip form structures.

Conduit risers except as otherwise required by serving utilities.

Surface mounted conduit other than conduit risers.

Couplings in cabinet foundations shall be Rigid Galvanized Steel. The stubouts above the couplings shall be Rigid Galvanized Steel with grounding bushings.

Conduit installed using the directional boring method shall be UL listed High Density Polyethylene (HDPE) Schedule 80, Carlon Bore-Gard Schedule 80 or Rigid Galvanized Steel. Connections to HDPE conduit shall be made with an approved mechanical coupler.

At all other locations, unless otherwise specified in the Plans, conduit shall be PVC or Rigid Galvanized Steel.

Conduit shall be laid to a minimum depth of:

48 inches below the bottom of ties under rail road tracks.

24 inches below the curb grade in the sidewalk area.

24 inches below finished grade in all other areas.

Conduit stub-outs within cabinet foundations shall be placed so that they do not interfere with cabinet installation. Modification of the cabinet to accommodate stub-out placement is not allowed.

A pull string rated for 200 lbs. or greater shall be installed in all spare conduit.

All conduit including spare conduits shall be installed with bushings. Rigid Galvanized Steel conduit shall be installed with insulated grounding bushings. PVC conduit shall be installed with molded one-piece bell end bushings.

All conduits including spare conduits shall be installed with plugs, which shall not be removed until installation of conductors or pull string. Upon installation of wiring, conduit shall be sealed with duct seal. Upon installation of the pull string, spare conduit shall be plugged

Conduit between light standards, PPB, PS or type I poles and the nearest junction box shall be the diameter specified in the Plans. Larger size conduit is not allowed at these locations.

Spacing of unistrut type channel supports for surface mounted conduit shall not exceed 5 feet.

Where Rigid Galvanized Steel conduit is installed:

Insulated grounding end bushings shall have standard threading, which extends around the entire circumference of the bushing.

Where PVC conduit is installed:

Conduit shall be schedule 40, with the exception that roadway crossings, and service lateral runs shall be schedule 80. The same schedule and type of conduit shall be used for the entire length of the run from outlet to outlet and from HDPE conduit crossing the roadway to the nearest junction box.

Eighteen-inch radius elbows shall be used for conduit of 2-inch nominal diameter or less.

Standard sweep elbows shall be used for conduit with greater than 2-inch nominal diameter unless otherwise specified.

With the exception of connections to HDPE conduit, joints shall be connected with medium grade gray cement solvent applied per the manufacturer's recommendations.

In conduit less than 2-inch nominal diameter, pull ropes for wire installation shall be not less than ¼ inch diameter. In conduit of 2 inch nominal diameter or larger, pull ropes for wire installation shall be not less than ½ inch diameter.

Trenches located within paved roadway areas shall be backfilled with 3 inches of sand over the conduit, followed by controlled density fill meeting the requirements of Section 2-09.3(1)E. Unless otherwise indicated in the Plans and approved by WSDOT, the controlled density fill shall be placed level to, and 3 inches below, the surface of the remaining pavement, followed by 3 inches of paving material that matches the existing material.

On new construction, conduit shall be placed prior to the placement of base course pavement.

Conduit Sealing
All conduit entering pad mounted ITS device cabinets shall be sealed with a mechanical plug at the pad entry area to prevent rodent entry.

Directional Boring
Where directional boring is called for, conduit shall be installed using a surface launched steerable drilling tool. Drilling shall be accomplished using a high pressure fluid jet toolhead. The drilling fluid shall be used to maintain the stability of the tunnel, reduce drag on the conduit and provide backfill between the conduit and tunnel. A guidance system which measures the depth, lateral position and roll shall be used to guide the toolhead when creating the pilot hole. Once the pilot hole is established a reamer and swivel shall be used to install the conduit. Reaming diameter shall not exceed 1.5 times the diameter

of the conduit being installed. Conduit which is being pulled into the tunnel shall be protected and supported so that it moves freely and is not damaged during installation. The pullback force on the conduit shall be controlled to prevent damage to the conduit. A vacuum spoils extraction system shall be used to remove any excess spoils generated during the installation. Excess drilling fluid and spoils shall be disposed of. The method and location used for disposal of excess drilling fluid and spoils shall be subject to WSDOTs approval. Drilling fluid returns (caused by fracturing of formations) at locations other than the entry and exit points shall be minimized. Any drilling fluid that surfaces through fracturing shall be cleaned up immediately. Mobile spoils removal equipment capable of quickly removing spoils from entry or exit pits and areas with returns caused by fracturing shall be used as necessary during drilling operations.

Junction Boxes, Cable Vaults, and Pull Boxes

Section 8-20.3(6) is supplemented with the following:

Wiring shall not be pulled into any conduit until all associated junction boxes have been adjusted to or installed in their final grade and location, unless installation is necessary to maintain system operation. If wire is installed for this reason, sufficient slack shall be left to allow for future adjustment.

Prior to construction of finished grade, if junction boxes are installed or adjusted, pre-molded joint filler for expansion joints may be placed around the junction boxes. The joint filler shall be removed prior to adjustment to finished grade.

Adjustments involving raising or lowering the junction boxes shall require conduit modification if the resultant clearance between top of conduit and the junction box lid becomes less than 6 inches or more than 10 inches. Wiring shall be replaced if sufficient slack as specified in Section 8-20.3(8) is not maintained.

The six-inch gravel pad required in Standard Plan J-11a shall be maintained. When existing junction boxes do not have this gravel pad, it shall be installed as part of the adjustment to finished grade.

Where conduit and junction boxes are placed in barrier, the Design-Builder shall coordinate the work of the subcontractor constructing the barrier and the electrical subcontractor so that each junction box placed in the barrier is placed in correct alignment with respect to the barrier, with the face of the box flush. The junction box shall be parallel to the top of the barrier within a 1-degree tolerance. If any point on the face of a junction box placed in barrier is recessed more than 1/8 inch from the surface of the barrier, the Design-Builder shall install a box extension per WSDOT's approval and grout around the extension or remove and replace the entire section of barrier.

All junction boxes placed within the traveled way or shoulders shall be type 4, 5 or 6.

Type 4, 5 and 6 junction boxes shall be installed in accordance with the following:

1. Excavation and backfill shall be in accordance with Section 2-09. Excavation for junction boxes shall be sufficient to leave 1 foot in the clear between their outer surface and the earth bank.

2. The junction box shall be installed on a level 6-inch layer of crushed surfacing top course, in accordance with 9-03.9(3), placed on a compacted or undisturbed foundation. The crushed surfacing shall be compacted in accordance with Section 2-09.3(1)E.

3. After installation, the lid shall be kept bolted down during periods when work is not actively in progress at the junction box.

4. Before closing the lid, the lid and the frame shall be thoroughly brushed and cleaned of all debris. There shall be absolutely no visible dirt, sand or other foreign matter between the bearing surfaces.

5. When the lid is closed for the final time, a liberal coating of anti-seize compound shall be applied to the bolts and nuts and the lid shall be securely tightened.

6. Hinges shall be located on the side of the box, which is nearest to adjacent shoulder. Hinges shall allow the lid to open 180 degrees.

Bonding, Grounding

Section 8-20.3(9) is supplemented with the following:

Where existing conduits are utilized, an equipment-grounding conductor shall be installed except for conduits with innerduct.

In addition to the conductors called for in the contract, all ITS conduits, other than the conduits with innerduct, shall be installed with an equipment-grounding conductor and bonding jumpers sized per NEC 250-122 or as approved by WSDOT during plan developedment (No. 8 minimum).

All new and existing junction boxes, cable vaults and pull boxes that a equipment-grounding conductor is pulled to shall be bonded in accordance to 8-20.3(9).

Locate wires shall not be connected to the equipment-grounding system. See "Location Wire and Warning Tape" sections in subsection **Communication Conduit System** for attachment of locate wires.

Supplemental grounding shall be provided at Signal Standards for Ramp Meters and Steel Sign Posts for Advance Warning Signs. Foundations for these standards shall be installed with a bare number 6 copper wire which is connected to the reinforcing cage with an approved acorn clamp or cadweld and routed to connect to the pole at the grounding lug.

Section 8-20.3 is supplemented with the following:

(NWR May 3, 2004)

For additional construction requirements, see Sections 8-20.3 as modified in the **Construction Requirements** subsection of the Special Provision **ILLUMINATION, TRAFFIC SIGNAL SYSTEMS, AND ELECTRICAL**.

Junction Box, Cable Vault and Pull Box Labeling

All junction boxes, cable vaults, and pull boxes used as part of the ITS System shall be labeled in accordance with Section 9-29.2(4).

Traffic Data Accumulation And Ramp Metering System

Materials

Section 9-29 is supplemented with the following:

Model 170E Controller
Each controller unit furnished shall meet the requirements specified in the Type 170E Traffic Signal Control Hardware Specification, FHWA IP-78-16, as currently amended and modified as follows:

1. The 170E CPU module shall operate a 68HC11F1 MPU at a crystal frequency of 8MHz. The MPU shall be socket mounted in a PLCC socket.

2. The EPROM shall be resident on the CPU module. The EPROM socket shall be a 32-pin lever-controlled ZIF device. The EPROM shall be either a 32K x 8 or a 128K x 8 device. The device size shall be jumper selectable.

3. Feature and Location switches shall be provided on the front portion of the CPU module. Each switch shall be an 8-position front-reading dip switch. The switches shall be addressed as follows:

   Location Switch at 7000 (Port A)
   Feature Switch at 700A (Port E)

4. There shall be one LED indicator located on the front of the CPU module. This LED shall be connected to bit 3 of Port G.

5. The 170E controller shall have a minimum of 28 kB of battery backed static RAM on the CPU module. RAM shall be continuous from location 0000 to 6FFF.

6. Four Asynchronous Communication Interface Adapters (ACIAs) shall be provided on the same board as the CPU. The ACIAs shall be 6850 ICs operating at a crystal frequency of 6.144MHz. Each ACIA shall have 5 programmable jumpers to select 5 communication baud rates (1200, 2400, 4800, 9600, 19200) for a total of 20 jumpers. All ACIAs shall be active. An IRQ status register shall be provided at75FF.

7. The Model 412C PROM module shall not be provided. A blank panel shall cover the PROM slot.

8. Two blank 27256 EPROM chips shall be provided with the CPU module.

9. Each controller shall have an ACIA C20 wrap-around with the following pin connections:

C20 Function Pin		C20 Function Pin	
(J) RTS	to	(M)	CTS
(J) RTS	to	(H)	DCD
(K) DATA-IN	to	(L) DATA-OUT	

(NWR September 9, 2002)
10. Each 170E controller shall include a drop/insert data modem.

Model 330 Cabinet
Traffic data station controller cabinet(s), *** $$1$$ ***, shall meet the requirements specified in Chapter 12 of the Type 170E Traffic Signal Control Hardware Specification, FHWA IP-78-16, as currently amended except as modified by the following:

1. Cabinets shall be fabricated of 0.125 inch sheet aluminum, 5052 alloy, with mill finish, in accordance with Section 9-29.13(7)D, Item number 1. Painted or anodized aluminum is not allowed.

2 Cabinet door shall be provided with a spring-loaded construction core lock capable of accepting a Best Lock Company CX series core finished by others.

3 Visual alarm light shall not be provided

4 Field wire terminals shall be labeled in accordance with the ITS Field Wiring Chart.

5. One shatterproof fluorescent interior cabinet lights with self-starting ballast shall be furnished on the top of the front rack. Door switch shall automatically turn on the light when the door is opened.

One controller unit shelf, which attaches to the front rails of the EIA rack, shall be provided in lieu of the two controller unit support angles. The shelf shall be fabricated from aluminum and shall be installed such that it does not interfere with access to any terminal block. The shelf shall contain a rollout flip-top drawer for storage of wiring diagrams and manuals.

Cabinet Accessories

Cabinet accessories for the Model 330 Cabinet shall be the same as the Model 334 Cabinet with the following exceptions:

1 The cabinet shall not contain a PDA 3.

2 There shall be no load switches.

3 A 24V swing out power supply shall be provided.

4. The display panel shall have 24 LED indicators for loops. It shall not have an Advance Warning Sign Control Switch, nor any Controller Output Indicators.

5. One input file shall be supplied, using 5.25 inches of rack height. One Model 222 Amplifier shall be included for every two loops.

6. The cabinet shall not contain a police panel nor a Model 204 Flasher Unit.

Model 334 Cabinet

Traffic data station and ramp meter controller cabinets furnished on this contract shall meet the requirements of Section 9-29.13(7)E.

Model 222 Loop Detector Amplifiers

Only self-tuning amplifier units shall be allowed. Model 222 loop detector amplifiers (as specified in FHWA IP-78-16) shall be rack-mounted, plug-in printed circuit boards, with all operational controls and indicator lamps located on the front panel. The edge of the card shall be provided with heavy gold-plated contact fingers to mate with an edge connector.

Physical Features:

Operational mode selector switch	One per channel to allow switching between presence and pulse mode.
Sensitivity selector switch	One per channel to allow independent selection of the sensitivity settings for each channel.
Indicator lamp	One per channel which shall be activated independently when vehicle presence is detected on corresponding loop.
Frequency switch	To allow selection of one of three frequencies of the detector amplifier to reduce crosstalk between units.
Power requirement	24 VDC with a dissipation of not more than 5 watts.
On/Off switch	One per channel to allow disabling of unused channels.

Digital System:
The unit's digital system shall be programmed to recognize the occurrence of an open loop and shall respond with a continuous call when an open loop occurs. When power outage occurs, the open circuit shall cause a continuous call.

Detector Output:
Output of the detector shall be an optically isolated solid-state device. The optic-isolation shall effect an open circuit when no vehicle is detected. This shall be the interface between the induction loop detector amplifier and the controller.

Traffic Signal Standards
Ramp meter signal standards shall meet the requirements of Standard Plan J-7a.

Traffic Signal Splice Material
Section 9-29.12(2) is revised to read:

Induction loop splices shall be either mastik type or moisture resistant two way heat shrink type meeting Mil Spec I-23053, or re-enterable type with semi-hardening epoxy filling compound that remains semi-flexible enclosed in a re-enterable rigid mold with end cap seals.

Type 170E, 170E-HC-11, 2070, 2070 Lite, ATC Controller Cabinets
Section 9-29.13(7)E is supplemented with the following:

Cabinets shall be fabricated of 0.125 inch sheet aluminum, 5052 alloy, with mill finish, in accordance with Section 9-29.13(7)D, Item number 1. Painted or anodized aluminum is not allowed.

Each Model 334 cabinet shall be equipped with a fully operable Type 170E controller equipped as specified in these Special Provisions.

One Model 222 amplifier shall be included for every two loops.

One reproducible drafting film and two non-fading copies of the cabinet-wiring diagram shall be furnished with each cabinet.

The sign relay coil shall draw (or sink) less than 75 milliamperes from the 170E controller and have a DPDT contact rating not less than 10 amperes.

Cabinet Wiring
Cabinet wiring shall conform to the details and diagrams in the Standard Detail Plans. The Design-Builder shall trim wiring to eliminate all slack and lace or bind together with nylon wraps or equal. All terminals shall be labeled. The cabinet shall be wired completely so that the only requirement to make a field location completely operational is to connect field, power and ground wires to appropriate terminals.

Construction Requirements

Section 8-20.3 is supplemented with the following:

Model 330 & Model 334 Cabinet Testing
Traffic data accumulation equipment shall undergo two separate sets of tests prior to final acceptance. Initially, the Design-Builder shall deliver the equipment to the WSDOT Signal Shop in Seattle, Washington for testing. These tests shall check the operation of each individual component as well as the component's ability to operate within the overall system.

Shop Testing
Shop testing shall consist of two separate stages:

a. Stage 1: Notification, Delivery and Assembly

b. Stage 2: Hardware and Systems Tests

Stage 1: Notification, Delivery and Assembly

Notification
The following documents shall be submitted to WSDOT along with a copy to the Northwest Region Signal Shop, not less than 10 working days before any equipment is delivered to the Signal Shop for testing:

(1) Design-Builder's representative for tests: name, title, address and telephone number.

(2) Inventory of items to be delivered including:

(a) The quantity of each item to be delivered;

(b) The number of maintenance and operations manuals to be delivered,

(c) The number of cabinet prints, equipment schematics, equipment manuals, et al., to be delivered;

(d) The contract number the equipment is being tested for.

(3) Certificate confirming that Type 170 Traffic Signal Control Hardware Specification FHWA IP-78-16, as currently amended, has been met. The certificate shall indicate type

and modes of equipment tested, date and place of test, and name of party responsible for conducting the test. The certificate shall include the serial number of the controller.

(4) Scheduled delivery date of equipment to the Shop.

The Shop will not accept equipment for testing without proper notification.

During Stage 1, the Design-Builder shall request in writing a Stage 2 start date from WSDOT. WSDOT will provide the Design-Builder with a written notice of the Stage 2 start date. This date represents the date that Contracting Agency personnel will begin testing the controllers and modems.

Delivery
Delivery shall be made to the Region Signal Maintenance Office located at:

3700 9th Ave. S.
Seattle, WA 98134
Attention: Lynne Fackler
(206) 764-4014

Delivery will be accepted only if all required equipment and materials described in the notification are on hand, between the hours of 6:30 a.m. to 2:00 p.m. Monday through Friday.

The Design-Builder shall be responsible for unloading all equipment and materials.

Assembly
All equipment shall be completely assembled in preparation for Stage 2 testing.

Stage 2: Hardware and Systems Test
WSDOT will limit the Stage 2 testing to 25 calendar days for two controller and cabinet assemblies with 2 additional calendar days for each additional controller and cabinet.

The tests will verify whether or not the equipment supplied meets Type 170 environmental and operating standards and provides the functions and operations required in this contract.

Only two failures in each controller and cabinet assembly will be allowed. A third failure will result in rejection of the assembly.

A malfunctioning load switch and/or detection amplifier will not be considered a failure. However, the Design-Builder shall provide replacement units.

The Design-Builder will be notified of all rejections. The Design-Builder shall remove all equipment that is rejected from the Shop within seven calendar days following receipt of the rejection notice. If not removed accordingly, the Shop will forward the equipment to the Design-Builder, freight collect.

Stage 2 testing may extend beyond the allowed test period if:

1. A controller and cabinet assembly fails within the last 7 calendar days of Stage 2; or

2. A controller and cabinet assembly that replaces a rejected assembly is submitted for testing.

In order to pass the Stage 2 test, the controller and cabinet assembly must have no failures during the last seven calendar days of the test period.

The Shop will release no equipment unless all documents are current and correct. Should any document require revising or updating, the Design-Builder shall provide two copies of that document with the changes marked in red. These documents include, but are not limited, to the following:

1. One reproducible mylar wiring diagram of each cabinet supplied.

2. Two blue-tone wiring diagrams of each cabinet supplied.

3. Wiring diagrams for all auxiliary equipment furnished. One set per cabinet.

4. Type 170E controller operations and maintenance manuals. One set per cabinet. The Design-Builder shall provide two extra sets over and above the total number required for all cabinets.

5. Auxiliary equipment operations and maintenance manuals. One set per cabinet.

All equipment except accepted controllers and modems shall be removed from the Shop within seven working days following notice of final approval and acceptance. If not removed accordingly, the shop will forward the equipment to the Design-Builder freight collect. Accepted controllers and modems shall remain in the shop until requested by the Design-Builder for the turn-on test.

Modem Testing
All modems will be tested using a Contracting Agency-owned communications data analyzer. The modems will be tested over a 24-hour period. Each modem is passed if the data analyzer detects no errors over a 24-hour period. Any modem failing the test will be rejected. The rejected modem shall be replaced at no added cost to WSDOT.

Controller Testing
Controller testing will be primarily communications oriented. However, a hardware failure shall cause the controller being tested to fail the test. Each controller will be tested for communications compatibility with the central computer over a 24-hour test period. The test will be considered successful if communications with the central computer are maintained over the test period.

Communication Failure
Failure to properly communicate with the central computer on each transmission during the 24-hour period shall cause the unit to fail the test. The Design-Builder shall diagnose the problem and document the solution upon notice of a failure.

Hardware-Oriented Problems
If the problem is hardware-oriented, the Design-Builder shall remove the failed unit from the TMC for repair or replacement. The repaired or replaced unit and its cabinet shall be delivered to the Shop for complete testing before re-testing at TMC.

Software-Oriented Problems
If the problem is software-oriented, the Design-Builder shall promptly notify TSMC personnel of the problem. The Design-Builder shall demonstrate that it is a software problem and not a hardware incompatibility in the controller, to both the Freeway Systems Engineer's and WSDOTWSDOT's satisfaction.

Work Delays
The Design-Builder will not be granted an extension of time for delays caused by rejected equipment.

Turn-On Test
Immediately following the field installation of the traffic data station controllers, the Design-Builder shall demonstrate that all functions of the controllers and cabinets operate as specified, specifically:

1. The ability of the cabinet to interface properly with field wiring and equipment. This shall include communicating with the central computer over the communication lines, and detecting vehicle presence and absence over all induction loops. The Design-Builder shall correct any interfacing problems resulting from this installation.

2. The ability of the controller to gather, store, and transmit field data to the central computer, including status of field equipment, as specified.

3. The ability of the controller to receive and process commands from the central computer.

The turn-on tests shall be conducted only during the time period between 9:00 a.m. and 2:30 p.m. The Design-Builder shall notify WSDOTWSDOT 10 days in advance of the demonstration and perform the demonstration in the presence of WSDOTWSDOT. TSMC personnel will be on-site to help in transmitting commands from the central computer to the controller(s) at the Design-Builder's request.

Warranty
In addition to the requirements of Section 1-05.10 **Guarantees**, the Design-Builder shall provide a one-year (minimum) manufacturer's warranty for major components of the traffic data accumulation and ramp metering system. These warranties shall be written by the manufacturer or authorized repair agent of said equipment and shall include parts and labor and return freight or shipping. The warranty shall name Washington State DOT Northwest Region Signal Maintenance Superintendent as the equipment owner. The warranty shall cover defects in material and workmanship under normal use. The State will be responsible for items damaged due to accidents, acts of God, misuse, negligence by the State, or by a third party. The following components shall be provided with a warranty:

Controller
Controller cabinet accessories
Loop amplifiers

The Design-Builder shall coordinate the warranty period with the manufacturer, or authorized repair agent of said equipment, to begin upon acceptance of the system. Acceptance of the system is defined as starting on the physical completion date of the contract or, if relief of responsibility is to be granted in accordance with Section 1-07.13(2), on the date WSDOTWSDOT relieves the Design-Builder from responsibility for the completed system.

The Design-Builder shall provide WSDOTWSDOT with a written copy of all manufacturers' warranties for the traffic data accumulation and ramp metering system. The warranty document shall denote that the warranty period begins upon acceptance of the system and not on product delivery.

Induction Loop Vehicle Detectors

Section 8-20.3(14)C is supplemented with the following:

Item 2 is deleted.

The last two sentences of Item 4 are deleted.

Item 11 is deleted.

Round Loops

Round loops shall be constructed in accordance with the following requirements:

1. Loop conductor and lead in cable shall conform to these Special Provisions.
2. Round sawcuts shall be 6 feet in diameter and shall be constructed using equipment designed for cutting round loops. The equipment shall use a concave, diamond-segmented blade. The sawcuts shall be normal to the pavement surface and shall be a minimum of 0.25 inches wide. The sawcut depth shall be a minimum of 2 5/8 inches and a maximum of 3 inches measured at any point along the perimeter, except on bridge decks. Other methods of constructing the round sawcut, such as anchoring a router or flat blade saw, will not be allowed.
3. The bottom of the sawcut shall be smooth. No edges created by differences in sawcut depths will be allowed.
4. All sawcut corners shall be rounded to a minimum 1.5 inch radius.
5. All sawcuts shall be cleaned with a 1000 psi high pressure washer as certified by the manufacturer's label on the machine or as measured by an in line pressure gauge. Wash water and slurry shall be vacuumed out and the sawcut shall be blown dry with compressed air. Sawcutting shall be subject to the requirements set forth in Section 1-07.5(3) and the subsection **Fish And Wildlife and Ecology Regulations** of the Special Provision **LEGAL RELATIONS AND RESPONSIBILITIES TO THE PUBLIC**.
6. Loops shall be installed after all grinding and prior to paving the final lift of asphalt.
7. The loop shall be constructed using four turns of conductor. The conductor shall be installed one turn on top of the previous turn. All turns shall be installed in a clockwise direction. The conductors shall be secured to prevent floating with 2 inch lengths of high temperature foam backer rod sized for a snug fit. The backer rod shall be spaced at 2 foot intervals around the perimeter of the sawcut and at corners.

8. Loop sealant shall be installed in two layers. The first layer shall be allowed to cool before the second layer is applied. Installation of the sealant shall completely encapsulate the loop conductors. A minimum of 1 inch of sealant shall be provided between the top of the conductors and the top of the sawcut. The twisted polypropylene rope noted in Standard Plan J-8a is not allowed.
9. Use of kerosene solvent is prohibited.

Existing Traffic Loops
The Design-Builder shall notify the Area Traffic Engineer through WSDOT a minimum of five working days in advance of pavement removal in the loop areas.

If WSDOT suspects that damage to any loop may have resulted or believes it possible that an existing loop is not operating adequately, WSDOT may order the Design-Builder to perform the field tests specified in Section 8-20.3(14)D. The test results shall be recorded and submitted to WSDOT. Loops which fail any of these tests shall be replaced.

If advance loops are replaced, they shall be installed immediately ahead of or behind the existing loops. The Design-Builder shall avoid cutting through the existing loop or lead-in.

If replacement loops are not operational within 48 hours, the Design-Builder shall install and maintain interim video detection at no additional cost to WSDOTWSDOT until the permanent loops are in place. The type of interim video detection furnished shall be approved by WSDOT prior to installation.

Test for Induction Loops and Lead-in Cable
Section 8-20.3(14)D is supplemented with the following:

An inductance level below 75 microhenries is considered a failure for a round loop.

Test A - The resistance shall not exceed values calculated using the given formula.

Resistance per 1000 ft of 14 AWG, R = 3.26 ohms / 1000 ft

$$R = \frac{3.26 \times \text{distance of lead-in cable (ft)}}{1000 \text{ ft}}$$

Permanent Traffic Recorder Station

Description
Section 8-20.1 is supplemented with the following:

The work shall consist of installing a controller cabinet, induction loop detectors, foundation, Contracting Agency supplied Class 2 piezo access sensors for permanent traffic recorder (PTR) station, and all associated equipment.

Materials
The cabinet shall be as shown in the Standard Plans and as specified in the subsection **Transformers and Cabinets** of this specification.

Equipment inside the PTR cabinet will be provided and installed by others.

Construction Requirements

Section 8-20.3 is supplemented with the following:

The Design-Builder shall notify WSDOT two weeks prior to beginning work on or near a permanent traffic recorder (PTR) station and installing class 2 Piezo Access Sensor.

PTR Contact:

Travel Data Supervisor
OSC Transportation Data Office
Telephone: (360) 570-2373

The Design-Builder shall cut loops in accordance with ITS special provisions and details.

The Design-Builder shall provide and install one covered terminal block and terminate the power cable from transformer on this terminal block.

The Design-Builder shall coil six feet of each 2C(SH) loop wire in the PTR cabinet for future termination. Each loop wire shall be labeled as shown on the Standard Plans.

Closed Circuit Television System

Materials

Section 9-29 is supplemented with the following:

(NWR June 7, 2004)

Television Camera Assembly

Television cameras shall be supplied as a unit including camera with integrated lens, id generator, camera controller, pressurized environmental enclosure, pan and tilt mechanism and rain/sun shade. The camera assembly shall be a 3950 series I-view system, manufactured by Cohu.

1. Equipment Model Numbers:

   I-View Camera system with integrated positioner:

   $$$1 CHOOSE 1 OF THE FOLLOWING:

Top pole mount	Model 3955-3100/PEDD
Side pole mount	Model 3955-3100/POLE
Wall mount	Model 3955-3100/WALL $$$

2. Manufacturer Information:

   Cohu Inc., Electronics Division
   PO Box 85623
   San Diego, CA 92186-5623
   Telephone: (858) 277-6700
   www.cohu-cameras.com
   info@cohu.com

Camera Pole(s)

The Design-Builder shall furnish and install round tapered steel poles for the CCTV camera installation, as shown in the Standard Plans. The camera pole installation shall include the pole foundations for the CCTV camera installation and all associated mounting hardware. They shall provide a flat mounting

surface at the top of the pole to attach the camera assembly. The mounting plate shall have a 1.75-inch hole to pass the camera connector into the top section of the pole. The plate shall also provide predrilled 7/16-inch bolt holes in a 4.75-inch bolt circle to match the base plate of the camera assembly. The Design-Builder shall design the poles, hardware, and components to the requirements as shown in the Standard Plans for each location.

Submittal
The Design-Builder shall submit all structural calculations and shop drawings to WSDOT for approval in accordance with Section 6-03.3(7), prior to fabrication of the poles and hardware.
(NWR October 21, 2003)
CCTV System Cabling
Cable connections between the camera system (Model 3955) and the control cabinet shall be as shown in the Standard Plans. The cable ends shall be factory terminated. Cable installation shall only require installing the connector shell at the camera end, and modifying the power cable at the cabinet end. The cable used between the CCTV camera and the camera control cabinet shall be:

CA297F	Cohu	Cable Assembly, 3955 control

Existing Camera Pole(s)
The Design-Builder shall modify the existing mounting plate by cutting a 1.75-inch hole to pass the camera connector into the top section of the pole. The Design-Builder shall also drill 7/16-inch bolt holes in a 4.75-inch bolt circle to match the base plate of the camera assembly. The mounting plate shall be painted with cold galvanizing paint to repair the finish damaged by drilling and cutting.

Camera Control Cabinet (Pad Mount)
The cabinet shall have the same external physical dimensions and appearance of Model 334 cabinets.

1. Cabinets shall be fabricated of 0.125” sheet aluminum, 5052 alloy, with mill finish, in accordance with Section 9-29.13(7)D, Item number 1. Painted or anodized aluminum is not allowed.

2. Cabinet doors shall have a three-point latch and two-position stop assembly with spring loaded construction core lock capable of accepting a Best Lock Company 6-pin CX series core. The Design-Builder shall supply green construction cores. Upon contract completion, the Design-Builder shall deliver two master keys to WSDOT.

3. The cabinet shall be equipped with an electric strip heater with a rating of 100 watts and 120 VAC and a ventilation fan meeting the requirements specified in Chapter 12 of FHWA IP-78-16.

4. The fan and strip heater shall be controlled by a high-low adjustable thermostat, which can be set to ensure the cabinet interior temperature remains between 60°F and 125°F. The heater strip shall be shielded.

5. Two shatterproof fluorescent interior cabinet lights with self-starting ballast shall be furnished, one fixture mounted on the rear rack near the top and the second mounted at the top of the front rack. Door

switches shall automatically turn on both lights when either door is opened.

6. The cabinet shall be equipped with a power distribution panel mounted on a standard 19-inch (ANSI/EIA RS-310-C) rack utilizing no more than five rack mounting spaces (8.75 inches). The following devices shall be provided with the power distribution panel:

    a. Duplex 120 VAC power receptacle.
    b. Main circuit breaker, 120 VAC, 20 amp.
    c. Four load circuit breakers, 120 VAC, 15 amp.
    d. Neutral bus.
    e. Ground bus.
    f. Surge suppresser and filter unit, 120 VAC, 50 amp.

   Power distribution panel components shall be mounted in or on the panel such that they are readily accessible, provide dead front safety, and all hazardous voltage points are covered to prevent inadvertent contact.

7. One controller unit shelf, which attaches to the front and back rails of the EIA rack, shall be provided. The shelf shall be fabricated from aluminum and shall contain a roll-out flip-top drawer for storage of wiring diagrams and manuals.

8. Each camera control cabinet shall house one termination block for termination of the camera control cable, the optical transmitter, and the camera control receiver. These cables shall be identified and marked by the Design-Builder.

9. The Design-Builder shall provide and install a rack-mounted fiber optic patch panel as shown in the Standard Plans and as specified elsewhere in these Provisions.

Camera Control Cabinet (Pole Mount)
Camera control cabinets shall contain the necessary equipment. The cabinet shall have the same features as the pad-mounted version except the dimensions shall be 36 inches high, 24 inches wide and 18 inches deep and include a single door. The cabinet and door shall meet the same requirements as the pad-mounted version. The cabinet shall include the following:

1. Cabinets shall be fabricated of 0.125” sheet aluminum, 5052 alloy, with mill finish, in accordance with Section 9-29.13(7)D, Item number 1. Painted or anodized aluminum is not allowed.

2. Cabinet doors shall have a three-point latch and two-position stop assembly with spring loaded construction core lock capable of accepting a Best Lock Company 6-pin CX series core. The Design-Builder shall supply green construction cores. Upon contract completion, the Design-Builder shall deliver two master keys to WSDOT.

3. The cabinet shall be equipped with a rack-mounted power distribution panel. The panel shall contain one duplex 120 VAC power receptacle for each camera, main circuit breaker (120 VAC, 15 amp), ground bus, neutral bus, and Surge suppresser and filter unit, (120 VAC, 50 amp). The power distribution panel components shall be mounted in or on the panel such that they are readily accessible, provide dead front

safety, and all hazardous voltage points are covered to prevent inadvertent contact.

4. Each camera control cabinet shall house one termination block for termination of the camera control cable.

5. The Design-Builder shall design, provide and install a rack-mounted fiber optic patch panel in consultation with WSDOT and as specified elsewhere in these Provisions.

6. The cabinet shall include a standard EIA 19-inch rack for mounting equipment.

CCTV System Cabling
Cable connections between the camera system (Model 3955) and the control cabinet shall be as shown in the Standard Plans. The cable ends shall be factory terminated. Cable installation shall only require installing the connector shell at the camera end, and modifying the power cable at the cabinet end. The cable used between the CCTV camera and the camera control cabinet shall be:

CA297F	Cohu	Cable Assembly, 3955 control

Construction Requirements
Section 8-20.3 is supplemented with the following:

CCTV Test
The Design-Builder shall test the CCTV system using a Design-Builder-supplied NTSC-compatible video monitor and a Design-Builder-supplied camera control device. The control device may be an IBM-compatible laptop computer with a suitable EIA-422 converter running Vendor-supplied software. The control device and monitor shall remain the property of the Design-Builder. All test cables and connections shall be the responsibility of the Design-Builder.

During each testing phase, the Design-Builder shall repair, replace, or reconfigure each CCTV camera installation as necessary, at no additional cost to WSDOTWSDOT.

Bench CCTV Test
The Design-Builder shall perform a bench test on each camera, pan-and-tilt unit, and camera controller prior to installation. The bench test shall be performed at a location proposed by the Design-Builder and approved by WSDOT. The bench test shall consist of the following:

1. Display camera video on Design-Builder-provided monitor.
2. Program I.D. generator.
3. Pan and tilt camera.
4. Zoom and focus camera in both fast and slow modes.
5. Turn camera off and on.
6. Change iris between auto and manual.

Local CCTV Test
At each camera control cabinet the Design-Builder shall connect the video monitor to the coaxial video cable and connect the camera control device to the camera control cable. The Design-Builder shall demonstrate to WSDOT the following features of the camera installation:

1. Display camera video on the Design-Builder-provided monitor.

2. Program the I.D. generator to display the State Route on line 1 and the CCTV camera number on line 2.
3. Pan and tilt the camera.
4. Zoom and focus the camera in both fast and slow modes.
5. Turn the camera off and on.
6. Change the iris to auto and manual.

HUB CCTV Test
At each hub the Design-Builder shall connect the camera control device to the EIA-232/422 converter. The video monitor shall be connected to the BNC port of the camera video receiver for the camera being tested. In the presence of WSDOT, the Design-Builder shall demonstrate all of the features listed in the Local CCTV Test section.

TMC CCTV Test
At the *** $$1$$ *** Traffic Management Center, the Design-Builder shall witness the TMC CCTV Testing as performed by WSDOTWSDOT. WSDOTWSDOT will attempt to perform all of the Local CCTV Test features through an existing TMS control console at the TMC.

Warranty
In addition to the requirements of Section 1-05.10 **Guarantees**, the Design-Builder shall provide a one-year (minimum) manufacturer's warranty for major components of the closed circuit television system. These warranties shall be written by the manufacturer or authorized repair agent of said equipment and shall include parts and labor and return freight or shipping. The warranty shall name Washington State DOT Northwest Region Signal Maintenance Superintendent as the equipment owner. The warranty shall cover defects in material and workmanship under normal use. The State will be responsible for items damaged due to accidents, acts of God, misuse, negligence by the State, or by a third party. The following components shall be provided with a warranty:

Television camera assembly
Controller cabinet accessories

The Design-Builder shall coordinate the warranty period with the manufacturer, or authorized repair agent of said equipment, to begin upon acceptance of the system. Acceptance of the system is defined as starting on the physical completion date of the contract or, if relief of responsibility is to be granted in accordance with Section 1-07.13(2), on the date WSDOT relieves the Design-Builder from responsibility for the completed system.

The Design-Builder shall provide WSDOT with a written copy of all manufacturers' warranties for the closed circuit television system. The warranty document shall denote that the warranty period begins upon acceptance of the system and not on product delivery.

Variable Message Sign (VMS)

Description
Section 8-20.1 is supplemented with the following:

This work shall consist of furnishing, installing and testing all materials and equipment necessary to complete in place the variable message sign system, and when specified, the modification of such an existing system.

Materials
Section 9-29 is supplemented with the following:

Sign Display
The sign display shall be a continuous matrix of pixels, 27 pixels high and 105 pixels wide. Each pixel shall be made from a grouping of amber light emitting diodes and contain no moving parts. The matrix of pixels shall be capable of displaying a message of 3 lines of text, 18 characters long. The sign display and other associated VMS components shall permit a test message using all 2,835 pixels, running at the maximum brightness and 100 percent duty.

VMS Sign Beacon
Three flashing beacons shall be installed on top of the sign housing. The beacons shall be as specified in Section 9-29.21. The 12 inch lamps shall be LED type, amber in color and meet the applicable portions of Section 9-29.16(2)A.

The beacons shall be aluminum and consist of single section, 12 inch traffic signal heads with cadet visor, square doors, and amber display. The center beacon shall flash alternatively to the two outside beacons.

Controllers for flashing beacons shall be as specified in Section 9-29.15, with aluminum sheet metal cabinets. The sign controller shall operate the beacons as commanded by the NTCIP communications protocol.

Sign Housing
The VMS housing shall provide walk-in service access for all LED display modules, electronics, power supplies, environmental control equipment, air filters, wiring, and other internal VMS components. The internal size of the housing shall be a minimum of 6 feet high. The access doors shall be a minimum of 2 feet wide by 6.5 feet high.

The nominal external dimensions of the sign shall not exceed 25 feet in width, 8 feet in height, and 4.25 feet in depth. The VMS back and side housing walls shall be vertical. The front VMS wall shall be built at an angle of 3 degrees toward the viewing motorists. Display modules shall be parallel to the front VMS wall, so that use of the LED viewing cone is optimized. The dead load of the housing and contents shall not exceed 3750 lbs.

VMS housing exterior sheet material shall be aluminum alloy number 5052-H34, and shall have a minimum thickness of 0.125 inches. Exterior sheet seams shall be continuously welded and waterproof. VMS housing structural frame members (I-beams, C-channels, Zee-extrusions, and bar stock) shall be aluminum alloy number 6061-T6.

The minimum distance from the interior rear wall of the VMS housing to the closest display components shall be 36 inches. This free space shall be maintained across the entire interior of the sign housing, with the exception of structural members. Structural members shall be designed and positioned so as to not be an obstruction to free movement of maintenance technicians throughout the interior of the housing. Circuit boards/display components shall be protected from accidental contact by maintenance personnel.

VMS housings shall be constructed to present a clean, neat appearance, and the equipment located within shall be protected from rain, snow, dirt, and corrosion. Sign housing floors shall contain small weep holes for draining water that accumulates due to condensation. Weep holes shall be fabricated in a manner which prevents the entrance of insects.

The front of the LED display matrix shall be completely covered with polycarbonate sheeting that is weather tight, ultraviolet (UV) light protected, non-glare, and which has a minimum thickness of 0.17 inches. To achieve maximum display contrast and legibility, the outside of the polycarbonate sign face shall be fully covered with a mask, which is formed from aluminum sheeting. The mask shall have a minimum thickness of 0.09 inches and shall contain a circular opening for each pixel. The openings shall not hinder the 15° LED viewing angle. All exposed metal on the VMS front face, which is visible to viewing motorists, shall be coated with black Kynar 500 resin or an equivalent oven-fired fluoropolymer-based coating having a minimum outdoor service life of 20 years. This shall include the aluminum face mask, the aluminum border outside the LED display matrix, and all the mounting and assembly hardware.

The VMS housing shall include a minimum of two (2) NEMA 20-R, 120 VAC duplex electrical outlets, with ground-fault circuit interrupters. One duplex outlet shall be located at each end of the inside of the VMS housing.

The VMS housing shall contain one (1) 4 foot, 40-watt fluorescent lamp for every 5 feet of VMS housing length. Lamps shall be evenly spaced across the inside roof of the VMS housing, so they can provide uniform light distribution for night time maintenance purposes. Fluorescent light assemblies shall be covered with a protective wire cage. Fluorescent light ballasts shall be rated for operation at 0°F. The fluorescent light circuit shall be controlled by a manual timer switch having an adjustable on time of two (2) hours.

All VMS equipment, components, modular assemblies and other materials located within the VMS housing shall be removable, transportable, and capable of being installed by a single technician utilizing a one-person aerial lift truck. VMS structural members are not included in this requirement.

Ribbon cable shall be protected at all points of physical contact where it touches metallic frameworks. Either the ribbon cable or the frame, or both, shall be wrapped with a protective covering where the cable touches the framework, to prevent cable insulation rub-through from road induced vibration in the sign framework.

The interior VMS environment shall be monitored and controlled by the sign controller. Environmental control shall be designed to maintain the internal VMS temperature at or below +140°F when the outdoor ambient temperature is at or below +115°F. The VMS environmental control system shall consist of four primary subsystems as follows:

Internal Temperature Sensors - The VMS shall contain two internally-mounted temperature sensors which are equipped with external thermocouples and which the sign controller continuously monitors. This temperature information shall be used by the sign controller to determine when to activate and deactivate the environmental control systems described herein. Sensors shall be located on opposite ends of the upper 1/3 of the LED display matrix, and their external thermocouples shall be attached to and make contact with an LED pixel circuit board.

The thermocouple and LED board shall be easily detached, in the event that one of the units requires removal and replacement. Sensors shall be capable of measuring temperatures from -40 to +185°F. The sign controller shall automatically shut down the LED display whenever one or both sensors indicate that LED board temperature has exceeded +140°F. The sign controller shall automatically restart the LED display whenever the suspect temperature falls below +130°F. Both shutdown and re-start

temperature thresholds shall be user-programmable. Sensor temperatures and VMS shutdown/re-start events shall be reportable to the VMS Central Software.

Housing Cooling System - The VMS housing shall contain a cooling system, which circulates outside air into the VMS housing whenever LED board temperature exceeds a user-programmable threshold. This system shall consist of enough ventilation fans as needed to exchange the internal VMS housing air volume at a minimum rate of 3.8 times per minute. Fans shall be the ball-bearing type. Exhaust fans shall be mounted in a line across the upper rear wall of the VMS housing and shall direct air out of the cabinet. There shall be one filtered air intake port for each exhaust fan. Intake ports shall be located in a line across the lower rear wall of the VMS housing. Intake ports shall contain a removable filter, which shall remove airborne particles measuring 5 microns in diameter and larger. The sign controller shall initially be programmed to activate the VMS housing cooling system whenever the LED board temperature exceeds +100°F and will turn the cooling system off whenever LED board temperature falls below +95°F. On the VMS housing rear exterior wall, all air intake and exhaust ports shall be covered on their top, front, and sides by an aluminum shroud fabricated from 0.090 inch aluminum sheeting. Shrouds shall be securely fastened to the VMS housing, and all shroud-to-housing interfaces shall be thoroughly gasketed to prevent water from entering the VMS. All air filters and fans shall be removable from inside the VMS housing. The VMS housing cooling system shall be controllable by an adjustable timer that will turn fans off after the set time has expired. The timer shall be adjustable to at least four (4) hours, and it shall be located just inside the VMS housing door, within easy reach of a maintenance technician standing outside the VMS doorway.

LED Display Cooling System - The VMS shall contain an LED display cooling system, which directs air across the LED display modules whenever LED board temperature exceeds a user-programmable threshold. This system shall be comprised of fan-forced air directed vertically across the back side of the entire LED display matrix. The air source shall consist of multiple ball-bearing fans. The sign controller shall initially be programmed to activate the LED cooling fan system whenever LED board temperature exceeds +110°F and shall deactivate the system whenever LED board temperature falls below +105°F. Cooling fans shall be located so as not to hinder removal of LED display modules and driver boards.

Front Face Panel Defog/Defrost System - The VMS shall contain a defog/defrost system which circulates warm, fan-forced air across the inside of the polycarbonate front face whenever LED board temperature falls below a user-programmable threshold. The air source shall consist of multiple ball-bearing fans that provide uniform airflow across the polycarbonate face panel.

The sign controller shall initially be programmed to activate the defog/defrost system whenever LED board temperature falls below +40°F and shall deactivate the defog/defrost system whenever LED board temperature exceeds +105°F. A 100-watt pencil-style heating element shall be mounted in front of each defog/defrost fan and shall serve to warm the air directed across the VMS face. Heating elements shall be on only when the defog/defrost fans are on.

Sign Mounting Hardware
A VMS, sign structure, foundation, and a maintenance walkway are included in the construction. The sign housing shall be provided with all necessary hardware including sign mounting beams, vertical and horizontal brackets, maintenance walkways, and all related hardware to install the VMS.

The maintenance walkway shall be a minimum of 5 feet wide measured from the face of the sign, and equipped with a folding handrail on the front of the walkway and either a safety chain or rail between the handrails. The walkway shall extend from the nearest edge of the pavement to 5 feet beyond the opposite end of the sign. A 5 foot platform shall be provided on both ends of the sign housing to service the access doors. The walkway shall be level with the bottom edge of the VMS. All mounting hardware shall be hot-dip galvanized or stainless steel and shall conform to the G series Standard Plans, the Standard Specifications.. All nuts used in the mounting hardware shall be self-locking nuts with nylon inserts.

The VMS housing, structural framing, face covering, and mounting members shall be designed to withstand a wind velocity of 100 mph with a 30 percent gust factor and shall otherwise comply with the latest requirements of AASHTO's *Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals.*

Ground-mounted VMS Field Cabinet
The field cabinet shall contain the necessary equipment The cabinet shall have the same external dimensions and appearance of Model 334 cabinets as specified in Chapter 12 of FHWA IP-78-16. The cabinet shall contain the main power feed from the 120/240v transformer.

1. Cabinets shall be fabricated of 0.125 inches sheet aluminum, 5052 alloy, with mill finish, in accordance with Section 9-29.13(7)D, Item number 1. Painted or anodized aluminum is not allowed.

2. Cabinet doors shall have a three-point latch and two-position stop assembly with spring-loaded construction core lock capable of accepting a Best Lock Company 6-pin CX series core. The Design-Builder shall supply red construction cores with two master keys and one core key per lock. The Design-Builder shall deliver the keys to WSDOT.

3. The cabinet shall be equipped with an electric strip heater and a ventilation fan. The strip heater shall be rated at 100 watts and 120 VAC and be shielded in a manner that prevents damage to nearby electrical cables. The ventilation fan shall be mounted in the top of the cabinet, be equipped with a screened guard, and exhaust at least 10 CFM.

   The fan and strip heater shall be controlled by a high-low adjustable thermostat, which can be set to ensure the cabinet interior temperature remains between 60°F and 120°F.

4. Two shatterproof fluorescent interior cabinet lights with self-starting ballast shall be furnished, one fixture mounted on the rear rack near the top and the second mounted at the top of the front rack. Door switches shall automatically turn on both lights when either door is opened.

5. The cabinet shall be provided with two 15 amp, 120 VAC duplex receptacles. One of the receptacles is for a laptop and/or tools and shall be GFCI-protected. The second receptacle is for communications equipment and shall not be GFCI-protected.

6. The cabinet shall be provided with three (3) circuit breakers. One circuit breaker shall be rated at least 20 amps and shall operate the heater, ventilation fan, receptacles, and lamps. The second circuit breaker shall be two-pole and control the power to the VMS defog/defrost heater elements. The third circuit breaker shall operate all other sign equipment. The second and third circuit breakers shall be rated in accordance with the NEC. Separate terminal strips shall be provided for each circuit breaker and an unfused terminal for the neutral side of the power supply line.

7. The cabinet shall be provided with two serial communication ports.

   One communication port shall be used to connect a laptop to the controller. The interface shall be wired as a 9-pin, EIA-232 DCE port. The port shall connect to a laptop computer using a straight-through 9-pin cable. One cable shall be supplied for each VMS installed in this contract.

   The second communication port is for remote control of the sign from the central computer. The interface shall be wired as a 25-pin, EIA-232 DTE port. This port connects to a communication interface (modem) specified elsewhere in this contract. A cable shall be supplied to connect the VMS communication port to the modem port (the modem port may be a non-standard pin-out and require a custom-made cable).

8. A reset button shall be provided in the cabinet that, when pressed, resets the VMS controller and all other VMS electronics.

9. A pullout shelf shall be provided in the cabinet to facilitate a laptop during local testing and control of the VMS.

10. Noise and voltage spike protection shall be provided in the cabinet as stated in the Transient Current Protection section of the Contract Provisions.

11. The conductor within the cabinet and the sign shall meet the requirements of Section 9-29.24. The conductors for communication shall be a minimum of 22 gauge.

Control System

The VMS control system shall include all excavation, backfill, conduit, wiring, and all hardware associated with providing power and communication between the local control cabinet and the sign. It shall also include writing, providing, and installing all software and any needed hardware to ensure the VMS is fully compatible with and completely capable of being operated by WSDOTWSDOT's existing Digital VAX computer system, while requiring no additional software or software modifications to be installed in WSDOTWSDOT's VAX.

Circuit Boards
The manufacturer's submittal shall include a schematic diagram for each type of circuit board used in the sign display and control system. Each circuit board used in the VMS display and control system shall conform to the following:

1. The printed circuit board through-hole for each LED cathode lead shall be connected to a large copper trace pad having a minimum surface area of 0.04 square inch. The trace pads shall dissipate heat from the LEDs and shall be present on both the front and rear sides of the LED pixel board.

2. All exposed metal (except connectors) shall be protected from water and humidity exposure by a thorough application of acrylic conformal coating. Bench level repairs to individual devices, including discrete LED replacement and conformal coating repairs, shall be possible.

3. Printed circuit laminate shall be FR-4 fiberglass, having a minimum thickness of 1/16 inch. The circuit board traces shall be copper. Through-holes shall also be plated with copper.

4. All cables attaching to circuit boards shall be held in place by locking latch connectors that firmly hold the cables in place.

Display LEDs
LEDs used in the VMS display shall be from one LED manufacturer and of one part number. LEDs shall conform to the following minimum requirements:

1. LEDs shall be un-tinted, non-diffused, high-output, solid state lamps utilizing Indium Gallium Aluminum Phosphide (InGaAlP) technology. The LED manufacturer shall be Toshiba or Hewlett-Packard.

2. The discrete LEDs size shall be T 1-3/4. LED package style shall be the through-hole flush-mount type, and all LEDs shall be soldered with the base of their lens mounted within 0.010 inches of the printed circuit board.

3. LEDs shall emit amber light, having a peak wavelength of 590 $\pm$ 5 nanometers. The half-life rating shall be 100,000 hours. Rated brightness per LED shall be a minimum of three (3) candelas.

4. LEDs shall be pre-sorted by the LED manufacturer for luminous intensity and color. LEDs used shall be obtained from a one-bin luminous intensity sort. A bin is defined such that when all LEDs from a given bin are driven with an identical forward current, the dimmest LED shall emit no less than half the luminous intensity of the brightest LED in the bin.

5. Operating temperature range shall be -22 to +185° F, and storage temperature range shall be -40 to +248° F.

6. Minimum half-power viewing angle shall be 15°. Half-power viewing angle is defined such that, at a given distance from the LED, luminous intensity measured at any point at an angle of 7.5° from the LEDs center axis shall be no less than half the luminous intensity measured directly on the LEDs center axis.

7. The discrete LED manufacturer's data sheet showing compliance with this Special Provision, and 10 samples, shall be provided with the VMS manufacturer's submittal.

LED Modules

The VMS shall be constructed with multiple display circuit boards, each of which contains no less than five (5), but no more than forty-five (45) pixels. Each pixel, which is defined as the smallest programmable portion of a display matrix, shall consist of a cluster of closely spaced discrete LEDs (strings of LEDs) and shall conform to the following requirements:

1. The distance from the center of one pixel to the center of all adjacent pixels, both horizontally and vertically, shall be 66.0 millimeters.

2. Each LED string shall be in series with its own current limiting resistor. Current limiting resistors shall be rated to limit LED string forward current to 30 milliamperes whenever a forward voltage is applied.

3. Each pixel shall contain a minimum two (2) string of LEDs. Each LED string shall contain a minimum six (6) LEDs.

4. The failure of an LED string shall not cause a change in the forward current of any other LED string, nor shall it cause the failure of any other LED string. Similarly, the failure of any LED pixel shall not cause the failure of any other pixel in the VMS.

5. Each LED pixel shall emit a minimum luminous intensity of 40 candelas when driven with a forward current of 20 milliamperes DC per LED string. An independent laboratory that utilizes equipment and procedures traceable to N.I.S.T. standards shall certify LED pixel intensity. The independent laboratory's certification report shall be provided with the VMS manufacturer's submittal. This report shall contain the laboratory name, address, and contact information. The report shall also contain a description of the test procedure and test equipment used, test personnel name(s), pixel intensity test results, date(s) the VMS manufacturer's LED pixel samples were tested, and the VMS manufacturer's name.

6. Discrete LEDs shall be mounted perpendicular to their PC boards. Any variations in discrete LED color and intensity shall be thoroughly dispersed throughout the entire display, thereby creating a uniform visual appearance of both color and intensity.

7. The sign controller shall be able to measure the forward current of each LED pixel and determine if the pixel is operating normally. This information shall be stored in a read-only NTCIP object.

LED Output Control

The LEDs shall be driven using Pulse Width Modulation (PWM) of a nominal 30 milliampere forward current, where pulse width is used to achieve the programmed LED intensity level for a given ambient lighting condition.

The current pulse shall be modulated from a 10-millisecond period, and pulse amplitude shall not be allowed to exceed 30 milliamperes per LED string. An illustration of the PWM drive current waveforms, which are used to achieve minimum and maximum LED intensity, shall also be provided with the VMS manufacturer's submittal.

LED Intensity Control System
The VMS shall be equipped with an LED intensity control system. The control shall support both manual and automatic control. LED intensity control shall consist of three (3) photo-sensors and associated circuitry. VMS controller analysis of these ambient light measurements shall automatically determine which of sixteen pre-programmed LED intensity levels will provide the best VMS legibility for the given ambient light condition. The LED intensity control system shall not cause flickering of the LED display.

The LED intensity control system shall conform to the following minimum requirements:

1. The VMS controller shall contain a read-write NTCIP object that adjusts the maximum usable intensity threshold, the Maximum Pulse Width Modulation (MPWM). This number is a percentage of the absolute maximum possible intensity. At the time of VMS delivery, MPWM shall be set to 67%. The LED intensity control system shall be designed such that a MPWM value of 100% delivers a time-average current of 30 milliamperes, and the MPWM value of 67% delivers a time-average current of 20 milliamperes.

2. Automatic intensity control shall select one of sixteen LED intensity levels based on the sensed ambient light. The threshold points for each intensity levels shall be user programmable. LED intensity levels shall be available in 1% increments and in a range of 1% to 100% of maximum display intensity.

LED Display Driver Circuit Boards
The VMS shall contain 9x5 LED display modules, which are constructed as follows:

1. LED pixel circuit boards shall be mounted to the back of an aluminum panel to form a 9 pixel high by 5 pixel wide LED display module. The pixel board(s) shall be mounted to the aluminum panel with durable, non-corrosive fasteners, and their removal from the panel shall not require use of tools.

2. One electronic driver circuit board shall be provided for each 9 high by 5 wide (9x5) LED pixel module and shall individually control all 45 pixels on that module.

3. Failure of a 9x5 driver board shall not cause the failure of any other 9x5 LED display module.

4. The LED display shall have a minimum refresh rate of 100 frames per second. The VMS manufacturer's submittal shall provide calculations that prove that the display conforms to this requirement.

5. The aluminum module panel shall have a minimum thickness of 1.5 millimeters, and it shall contain a circular opening for each LED pixel. The openings shall be sized so they do not block any portion of the 15° LED viewing cone.

6. The front side of the aluminum module panel, which faces the viewing motorists, shall be primed and coated with flat black paint.

7. Display modules and all of their components shall be easily replaceable from inside the VMS housing. Display modules shall mount securely to a support frame located inside the sign housing using durable, non-corrosive hardware. Module removal and replacement shall be accomplished with the use of simple hand tools or no tools.

8. All display module electrical connections shall be the quick-disconnect locking connector type. Removal of a 9x5 display module from the VMS, or a pixel board or driver board from its display module, shall not require a soldering operation.

Power Supplies
The LED display matrix shall be powered by regulated switching DC power supplies that operate from 120 VAC input power and have an output of 24 volts DC or less. Power supplies shall be wired in a redundant parallel configuration that uses multiple supplies per display. The supplies shall have a "current sharing" capability, that allows them to provide equal amounts of current to their portion of the LED display. Power supplies shall be rated such that if one supply fails, the remaining supplies will be able to operate their portion of the display under full load conditions (all pixels on at maximum drive current) while in an ambient temperature of +60° C.

Power supplies shall operate within a minimum input voltage range of +90 to +135 volts AC. Power supply output at an ambient temperature of +60° C shall be no less than 65% of its room temperature (+21° C) output. Power supply efficiency shall be a minimum of 74%. Power supplies shall have a minimum power factor rating of 0.95. Power supplies shall be short circuit protected. Under short circuit conditions, the DC side of the power supply shall be powered down. The power supplies shall reset automatically after 5 seconds of AC power off. Power supplies shall be protected by a minimum overload allowance of 105%. Inputs to power supplies shall be fused or circuit breaker protected. A failed power supply shall not interfere with the other operating power supplies.

The VMS sign controller shall be capable of monitoring the operational status ("normal" or "failed") of each individual power supply by reading a diagnostic signal located on the supply's DC output.

A copy of the power supply manufacturer's data sheet and its UL product card shall be provided with the VMS manufacturer's submittal.

The VMS manufacturer's submittal shall contain calculations demonstrating that the power supplies are rated for the criteria in this Special Provision. These calculations shall account for power supply output de-rating at a temperature of +60° C.

Transient Current Protection
VMS and sign controller signal and power inputs shall be protected from electrical spikes and transients.

AC power for all equipment shall be protected at the load center inside the field cabinet. A parallel-connection surge suppresser, rated for a minimum surge of 10 kJ, shall be connected to the load center in a manner that protects the load center and the equipment it feeds.

AC power for control equipment, such as the field controller and modem, shall be further protected by the use of a series-connected surge suppresser

capable of passing 15 Amps of current. This device shall be UL 1149 recognized.

EIA 232/485 communication ports in the sign controller shall be protected by avalanche diodes rated for 11.5 Volts at 10 Amps and 14 Volts at 70 Amps. The diodes shall be and connected between each signal line and ground.

Digital input and output lines from the VMS to the control equipment shall be protected at the control equipment by optically isolated input and output modules, or optically-isolated solid state relays. Inputs shall include, but shall not be limited to the VMS regulated power supply diagnostics and the AC power failure alarm. Outputs shall include, but shall not be limited the cooling fan and defog/defrost fan control.

VMS Sign Controller

Each VMS shall include an associated sign controller, which shall be installed in the sign housing. The sign controller hardware and software shall support all VMS communication, control, and diagnostic features as listed herein.

Memory

Sign controllers shall have both permanent and semi-permanent memory. Permanent memory shall be EE-PROM integrated circuits and shall contain the executable sign controller software. Semi-permanent memory shall be RAM integrated circuits with a battery backup that retains the data in memory for a minimum of one year following a power failure. Semi-permanent memory shall contain the library of messages, the message display schedule and programmable operating parameters. Each message shall have the capability to be defined and stored as a three-page message.

Power Interruptions

Contents of the sign controller's memory shall be preserved by battery backup during AC power interruptions and the controller shall automatically resume operation once AC power is restored. Upon recovering from a power interruption, the sign controller shall display the message identified by the Power Recovery Message parameter. The sign controller shall report to the central computer that it has recovered from a power interruption.

Sign Controller Software

The sign controller shall cause the desired message to be displayed on the VMS. The sign shall display alphanumeric character fonts. The sign controller shall provide a default value for each NTCIP object supported.

Message Selection

The central computer or laptop computer shall cause the sign controller to implement a message selected from those stored in controller memory, or a new message entered via the communication port.

The sign controller shall incorporate CRC checks to verify MULTI strings. The sign shall not display a message unless the MessageActivationCode CRC matches the MessageCRC.

A message shall remain displayed on the sign until either a command to change the current message or a command to blank the display is received. A command to display a message shall not succeed if the activation priority is less than the run time priority of the message currently displayed.

Data Transmission Requirements
Each sign controller shall contain two communication ports. Each communication port shall be labeled ("Local" or "Central") and shall be set to 9600 baud at the factory. Each port shall operate independently at baud rates of 1200, 2400, 9600, and 19,200 bits per second. The user shall select the baud rate for each port via a DIP switch.

Communication
The sign controller hardware and software shall communicate with the central computer in a polled multi-drop operation. In the polled multi-drop operation, several sign controllers shall share the same communication channel, with each controller assigned a unique ID number. Controller ID numbers shall conform to the NTCIP requirements for address numbers. A sign controller shall only reply to messages labeled with its ID. In polled multi-drop mode, sign controllers never initiate communication, but merely transmit their responses to messages from the central computer.

A laptop computer connected to the sign controller's local communication port shall have the same control and diagnostic capabilities as the central computer. However, local laptop control capability shall be limited to the VMS which is directly connected to that sign controller.

NTCIP Requirements
The sign controller software shall comply with the National Transportation Communications for ITS Protocol (NTCIP) documents and all related errata sheets published before July 1, 1999 and as referenced herein.

The sign controller software shall support the following standards:

1. NTCIP 1101, *Simple Transportation Management Framework* (STMF), Conformance Level 1 (Simple Network Management Protocol (SNMP))

2. NTCIP 2001, *Class B Profile*. All serial ports on the device shall support communications according to these standards.

3. NTCIP 2101, *SP-PMPP/RS232* Point-to-Multi-Point Protocol (PMPP)

4. NTCIP 2201, *NTCIP TP-Null* Transport Profile Null (TP-NULL)

The sign controller software shall implement all mandatory objects of all mandatory conformance groups as defined in NTCIP 1201, *Global Object Definitions*, and NTCIP 1203, *Object Definitions for Dynamic Message Signs*. Software shall implement the following conformance groups:

NTCIP 1203, Object Definitions for DMS

1. VMS Sign Configuration
2. MULTI Configuration
3. Default Message Control
4. Pixel Service Control
5. MULTI Error Control
6. Sign Status
7. Status Error
8. Pixel Error Status
9. Lamp Error Status
10. Fan Error Status

11. Power Status
12. Temperature Status

The software shall implement the following optional objects:

NTCIP 1203, Object Definitions for DMS

1. dmsMessageBeacon
2. dmsMessagePixelService
3. dmsCommunicationsLossMessage
4. dmsPowerLossMessage
5. dmsTimeCommLoss
6. dmsMultiOtherErrorDescription
7. dmsStatDoorOpen
8. fanFailures
9. fanTestActivation
10. lineVolts
11. tempMaxSignHousing

Objects required by these specifications shall support all values within its standardized range. The standardized range is defined by a size, range, or enumerated listing indicated in the object's SYNTAX field and/or through descriptive text in the object's description field. The following list indicates the modified object requirements for these objects.

Object Name	Object ID	Minimum Requirements
Number of Fonts	numFonts	9
Maximum Characters per Font	maxFontCharacters	255
Default Background Color	defaultBackgroundColor	0
Default Foreground Color	defaultForegroundColor	9
Default Justification Line	defaultJustificationLine	2, 3, and 4
Default Justification Page	defaultJustificationPage	2, 3, and 4
Number of Permanent Msgs.	DmsNumPermanentMsg.	2
Maximum No. Changeable Msg.	DmsMaxChangeableMsg.	8
Maximum Number Volatile Msg. *	dmsMaxVolatileMsg.	8
Control Mode	dmsControlMode	2, 4, and 5

* Changeable messages in excess of the minimum requirement are considered to meet the specification for an equivalent number of Volatile messages.

The first permanent message shall be used to blank the sign display. The second permanent message shall be the diagnostic message.

Sign controller software shall implement the following tags (opening and closing where defined) of the Mark-Up Language for Transportation Information (MULTI) as defined in NTCIP 1203:

1. Flash
2. Font
3. Justification Line
4. Justification Page
5. Moving Text
6. New Line
7. New Page
8. Page Time

Documentation
Software shall be supplied with all documentation on 1.44Mb IBM-compatible diskette(s). ASCII versions of the following Management Information Base (MIB) files in Abstract Syntax Notation 1 (ASN.1) format shall be provided on CD-ROM:

1. The official MIB Module referenced by the device functionality.

2. A manufacturer-specific version of the official MIB Module with the non-standardized range indicated in the SYNTAX field. The filename shall match the official MIB Module, with the extension "spc".

3. A MIB Module of all manufacturer-specific objects supported by the device with accurate and meaningful DESCRIPTION fields and the supported ranges indicated in the SYNTAX field.

Control Software
This work shall consist of furnishing Variable Message Sign (VMS) control software. The control software shall be a 32-bit application, designed to operate on Microsoft® Windows NT™, 98™, or 2000™ operating system. The control software shall provide for command and control of the following functions:

VMS Control
Software shall retrieve, display, update and download/upload the following functional parameters to the local sign controller in response to user-initiated instructions. The sign controller shall not perform pixel service tests when VMS are displaying messages. Software shall perform the following operations in conjunction with its monitoring and logging functions:

Display a message
Blank the current message
Change message priority
Pixel service, lamp and fan tests
Set time and date in the sign controller
Retrieve sign controller ID, type, and manufacturer

Communications
Communications between the control software and sign controller shall be NTCIP compliant, as indicated in the Special Provision for Variable Message Sign System.

The control software shall verify all communications for errors. If a response from a sign controller contains a communication error, or if there is no response, the Control Software shall re-establish communications.

Data Collection
The control software shall retrieve errors detected, message number currently being displayed, and current message priority. Using different commands, the software shall retrieve message MULTI strings, a map of defective pixels, the time and date, the event schedule, and configuration parameters.

Message Library
The control software shall store messages and transfer messages to a sign for storage and/or display. When a user desires to send a message to a sign, the control software shall offer as choices only those messages compatible with the sign in question. The control software shall allow message names of up to 25 characters in length. If the selected name already exists, the software shall notify the user and give the option of replacing the existing message or selecting another name.

The control software shall display all character fonts supported by the Variable Message Sign System. Messages shall be displayed on the computer monitor in exactly the same format (font, text centering and justification) as on the Variable Message Sign.

Software Duplication Rights
The Department shall have the right to duplicate the Variable Message Sign Control Software as needed for use in controlling signs under its jurisdiction.

Documentation
The Design-Builder shall furnish five (5) copies of the Control Software user manuals to WSDOT. In addition, three (3) sets of the software, installation program, instructions and user manual shall be furnished on CD ROM or diskettes to WSDOT.

Construction Requirements

Section 8-20.3 is supplemented with the following:

Order of Work
The installation of the sign support structure, sign power service, communications to the WSDOT central computer, delivery from manufacturer, installation, and testing shall be shown in the Design-Builder's CPM schedule. The Design-Builder shall install the VMS within 14 calendar days of delivery from the manufacturer. Within 24 hours of its installation, power shall be supplied to the VMS and its environmental controls fully operational. Also, the Design-Builder shall have the VMS fully operational and ready to begin testing procedures within 14 calendar days of VMS installation.

System Testing
Testing of the VMS hardware and software furnished and installed for this Contract shall be the responsibility of the Design-Builder. All variable message signs, VMS control software, VMS control equipment, and cabinets shall be inspected and tested prior to shipment from the factory and after installation in the field. These tests shall demonstrate that each component is fully functional and conforms with these Special Provisions. At a minimum, the tests shall show that all pixels are operational and that the control software provides LED brightness, housing ventilation, message and beacon control. All components that fail a test shall be replaced and re-tested.

The Design-Builder shall provide a copy of all Factory Test reports to WSDOT at the time of shipment. The Design-Builder shall provide WSDOT with a copy of the Field Test reports for each VMS, once the VMS equipment is found to be fully functional. The test reports required by this specification shall include:

1. a list of all equipment used to perform the tests
2. a record of each test step, who performed the tests, who witnessed the tests, and the test results
3. a record of test failures, corrective action taken, and results of the retest

WSDOT reserves the right to perform any independent inspections or tests, which are deemed necessary to ensure that the VMS equipment and software complies with the requirements of the Special Provisions.

NTCIP Testing
VMS sign controllers will be tested by the Department using the NTCIP Exerciser in place of the Central Computer. The NTCIP test will use the circuit created to connect the sign controller to the central computer, the modem furnished for this Contract, and the Department's copy of the Exerciser. The Exerciser shall prove that VMS sign controller fully complies with the NTCIP requirements of this Special Provision. WSDOT shall decide any differences in the interpretation of NTCIP Standards. The Design-Builder shall be responsible for ensuring that the VMS equipment fully complies with NTCIP standards specified herein. The Design-Builder shall allow 14 days for NTCIP testing. The System Acceptance Test will begin upon completion of the NTCIP test.

Acceptance Testing
The VMS sign shall be tested in order to check the operation of the sign. A representative from the manufacturer shall be present during testing of the VMS. A VMS operation manual shall be provided to WSDOTWSDOT at the time of the test.

During the 20 day test, the Design-Builder shall replace all failed sign components.

The Design-Builder shall verify remote control of the sign from the Traffic Management Center at Dayton Avenue before scheduling any testing. The Design-Builder shall demonstrate to the satisfaction of WSDOT that the sign, as a minimum can display diagnostic messages originating from the Dayton Avenue control consoles. Messages shall incorporate the use of the beacons. Testing shall not begin until the sign's basic features have been demonstrated to the satisfaction of WSDOT.

The test shall be conducted immediately following the complete installation of the new VMS. The Design-Builder shall demonstrate that all functions of the signs and local controllers are operational. This test shall be conducted in the presence of WSDOT.

Upon satisfaction of WSDOT that all functions of the system are operational, a 20-day test period of continuous operation shall begin. The test period shall be shown in the Design-Builder's CPM schedule. The following shall be observed during the test period:

1. All equipment shall be in working order at the beginning of the test. Any adjustment or replacement of components shall be considered a malfunction and cause for termination of the test period.

2. The system shall operate for 20 consecutive days without malfunction.

3. The VMS shall be communicating with the central computer during the entire 20-day test. Any loss of communication between the VMS and the central computer shall be considered a malfunction.

4. Although it is not necessary for the Design-Builder to provide personnel to be in attendance during the 20-day testing period, upon being informed of a malfunction, the Design-Builder shall respond within 48 hours with a representative who is thoroughly familiar with the operation of all parts of the system.

5. Upon detection of a malfunction, the test and test time shall be stopped and the malfunction corrected. Test time will be reset and a new 20-day test period shall begin.

Warranty
In addition to the requirements of Section 1-05.10 **Guarantees**, the Design-Builder shall provide a one-year (minimum) manufacturer's warranty for major components of the VMS system. These warranties shall be written by the manufacturer or authorized repair agent of said equipment. The warranty shall name Washington State DOT Northwest Region Signal Maintenance Superintendent as the equipment owner. The warranty shall cover defects in material and workmanship under normal use. The State will be responsible for items damaged due to accidents, acts of God, misuse, negligence by the State, or by a third party. The following components shall be provided with a warranty:

Sign display
VMS sign beacon
Sign housing
Sign mounting hardware
VMS field cabinet
Control system
Circuit boards
Display LEDs
LED modules
LED output control
LED intensity control system
LED display driver circuit boards
Power supplies
Transient current protection
VMS sign controller
Sign controller software
Control software

The manufacturers' warranties shall include on-site parts and labor for the VMS sign and VMS field cabinet and controller.

Repair of any failed component of the VMS sign shall be coordinated with the NWR Signal Maintenance Superintendent and shall commence within seven days of notification of a problem with the VMS sign. For VMS sign warranty repairs, WSDOT maintenance will provide access to the VMS sign and any necessary traffic control. Contact information is as follows:

NWR Regional Signal Maintenance Superintendent
3700 9th Avenue S
Seattle, WA 98134
(206) 764-4065

The manufacturer shall provide software upgrades during the warranty period at no cost to WSDOTWSDOT.

The Design-Builder shall coordinate the warranty period with the manufacturer, or authorized repair agent of said equipment, to begin upon acceptance of the system. Acceptance of the system is defined as starting on the physical completion date of the contract or, if relief of responsibility is to be granted in accordance with Section 1-07.13(2), on the date WSDOT relieves the Design-Builder from responsibility for the completed system.

The Design-Builder shall provide WSDOT with a written copy of all manufacturers' warranties for the VMS system. The warranty document shall denote that the warranty period begins upon acceptance of the system and not on product delivery.

VMS Training
The Design-Builder shall provide 8 hours of VMS system training for 5 Contracting Agency personnel taught by a manufacturer certified instructor. This shall include classroom instruction at a Contracting Agency facility as well as at the VMS location. Training shall focus on removal and replacement of sign components and manufacturers standard troubleshooting procedures.

Highway Advisory Radio Transmitter (HART)

Description
Section 8-20.1 is supplemented with the following:

The Design-Builder shall furnish all labor, materials, tools, equipment and services for the installation of a fully operational Highway Advisory Radio Transmitter (HART) as intended by the Special Provisions and Standard Plans. The HART shall include, but not be limited to: amplitude modulated transmitter with power supply, antenna, voice storage unit, cabinet, conduits, conductors, junction boxes, and power and communication services.

The Design-Builder shall design provide and install the HART.. The HART will be controlled remotely from the Traffic Management Center (TMC) at Airport Way in Bellingham by the use of Contracting Agency-owned communication lines.

Materials
Section 9-29 is supplemented with the following:

Amplitude Modulated Transmitter
The amplitude modulated transmitter shall be of a FCC accepted type installed in a control cabinet and operate on a frequency of 530 KHz. The transmitter unit shall be the equivalent of the AM 10WS AM transmitter manufactured by Audio-Sine, Inc., of New Hope, Minnesota. The transmitter shall be operational from -29°C to +60°C. The transmitter shall be totally solid-state with a crystal oscillator having a frequency stability of ±100Hz; a transistor driver and a single output transistor for the RF amplifier. The RF output shall be adjustable between 0 to 10 watts, into

nonreactive load at 50 ohms with a power adjustable potentiometer. The modulation shall follow the setting of the power adjustment potentiometer to ensure that constant desired percentage of modulation remains regardless of desired RF output.

The transmitter shall be supplied with a power supply unit to convert 115 VAC 60 Hz input to a regulated 24 VDC output.

The transmitter shall also meet the following specifications:

Spurious Emissions	Greater than 53 dB below carrier level.
Modulation	AM up to 100%
Sideband Spectrum (Modulated)	at frequencies 5.0 KHz either side of 530 KHz greater than -25 dB. At frequencies greater than 10 KHz either side of 530 KHz at least -35 dB and at 20 KHz either side of 530 KHz at least 51 dB.
AF Harmonic Distortion	Less than 5% at 67% modulation
AF Frequency Response	+1 to -3 dB between 300 and 3000Hz. 10 dB roll off from 2500 -5000 Hz without audio compression
Bandwidth Limiting	Audio Bandwidth Filter to limits bandwidth to ±3 KHz from 530 KHz

The transmitter shall be installed in a model 334 controller cabinet. The Design-Builder shall develop the plans necessary for this installation. The Design-Builder shall obtain the approval of WSDOT prior to installation.

Antenna
The antenna system shall match the 530 KHz transmitter frequency. The antenna shall be equivalent to a Model SF-530A Morad antenna. The antenna shall be base or center loaded vertical featuring a low-loss, embedded, weatherproof loading coil. The antenna shall be such that it can be tuned to resonance at mounting heights between 7.62 meters and 9.14 meters above the ground. The antenna shall be rugged and able to withstand winds of up to 130 km/h without ice buildup, and 81 km/h with 13 mm of ice buildup.

The antenna shall be mounted on a wood post. with appropriate hardware.

The antenna system shall be manufactured by Information Station Specialists (ISS), include the installation of a pre wired groundplane consisting of bare #12 copper conductors placed in a plane 6.5 mm in radius from the antenna The groundplane shall be buried at a depth of 305 mm.

Manufacturer:
Information Station Specialists
128 West Central
P.O Box 51
Zeeland, MI 49464

Telephone: 616 (772-2300)

Voice Storage Unit
The digital voice storage unit shall be able to record and playback human voice messages by the use of a solid-state memory. The memory storage time shall be a minimum of 8 minutes. Integrated memory circuits shall digitally store the voice message.

The voice storage unit shall operate on 120VAC, 60 Hz. The unit shall operate in a temperature range between –30°C to +70°C. The record input to playback frequency response shall be +3db from 300 Hz to 2500 Hz. The unit shall be mountable in a 482.6 mm (19 inch) rack within the HAR cabinet.

HART Cabinet
The HART Cabinet shall be a Model 334 Controller Cabinet meeting the requirements of the subsection **Traffic Data Accumulation And Ramp Metering System** of these specifications except it shall not include the 170 controller, input files, Model 222 amplifiers, power distribution assembly, transfer relay, police panel, display panel, and sign flasher.

The cabinet shall be equipped to house the transmitter, voice storage unit, a six-breaker distribution panel, one standard duplex receptacle, and one GFI duplex receptacle.

Communication Connection

1. Type R66B, six-pair, six-position, quick-connect terminal block. Each block shall contain 12 rows with six clips each.

2. Type RJ11 jack.

Construction Requirements
Section 8-20.3 is supplemented with the following:

General
The Design-Builder shall provide and install one FCC type accepted amplitude modulated transmitter in the control cabinet.

The Design-Builder shall provide and install the antenna system to match the 530 KHz transmitter frequency.

Communication Connection
This Design-Builder shall install the following conduit and communication cable between the HART cabinet and a terminal cabinet:

1. The Type R66B, six-pair, six-position, quick-connect terminal block shall be mounted in the back of the cabinet.

    a. Each row of the terminal block shall be clearly and permanently marked with the number of the cable pair that is attached.

b. Within each row the clips shall be electrically connected within the block so as to form two sets of three adjacent clips.

2. The Design-Builder shall install the type RJ11 jack near the controller and cross-connect it to pair 6 on the Type R66B terminal block.

Service
The Design-Builder shall provide the necessary hardware to provide service to the HART cabinet from the service point indicated in these Special Provisions.

Acceptance of the System
The Design-Builder shall demonstrate the complete operation of the HART to the State Radio Engineer and WSDOT. The HART shall transmit for 48 hours continuously without a failure or interruption of operation of any component in the system.

The Design-Builder shall measure and document the signal level of the transmitter to show that the transmitter field strength is 1.97 mv/m. at a distance of 1.6 km from the antenna in accordance with FCC requirements. Copies of this documentation shall be provided to WSDOT.

All manufacturers' warranties or guarantees on all electrical and mechanical equipment of the system shall be assigned to WSDOTWSDOT upon completion of the Design-Builder's warranty period.

The Design-Builder shall provide three sets of documentation regarding the operation, routine maintenance, trouble-shooting, and repair of the system.

Warranty
In addition to the requirements of Section 1-05.10 **Guarantees**, the Design-Builder shall provide a one-year (minimum) manufacturer's warranty for major components of the HART system. These warranties shall be written by the manufacturer or authorized repair agent of said equipment and shall include parts and labor and return freight or shipping. The warranty shall name Washington State DOT Northwest Region Signal Maintenance Superintendent as the equipment owner. The warranty shall cover defects in material and workmanship under normal use. The State will be responsible for items damaged due to accidents, acts of God, misuse, negligence by the State, or by a third party. The following components shall be provided with a warranty:

Amplitude modulated transmitter
Antenna
Voice storage unit
HART cabinet accessories

The Design-Builder shall coordinate the warranty period with the manufacturer, or authorized repair agent of said equipment, to begin upon acceptance of the system. Acceptance of the system is defined as starting on the physical completion date of the contract or, if relief of responsibility is to be granted in accordance with Section 1-07.13(2), on the date

WSDOT relieves the Design-Builder from responsibility for the completed system.

The Design-Builder shall provide WSDOT with a written copy of all manufacturers' warranties for the HART system. The warranty document shall denote that the warranty period begins upon acceptance of the system and not on product delivery.

Highway Advisory Radio Sign (HARS)

Description
Section 8-20.1 is supplemented with the following:

This work shall consist of furnishing, installing and testing of new sign and beacons, sign control equipment and cabinet, and other equipment necessary to provide for an operational highway advisory radio system as specified in these Special Provisions.

Materials
Section 9-29 is supplemented with the following:

Flashing Beacons
Two 203 mm, with round visors, amber beacons shall be provided with each sign assembly. The signal display shall meet the requirements of Section 9-29.16. The flashing beacon control shall meet the requirements of Section 9-29.15. The beacons shall flash alternately. The flashing control shall be designed to be accessible from inside the cabinet.

Sign Lighting Luminaires
The sign lighting luminaires shall consist of standard sign lights in accordance with Standard Plan G-9 except for the shoulder mount sign, where the sign light shall be mounted on top. The Design-Builder shall include a top mount kit for the sign light for this location.

Model 334 Cabinet
Controller cabinet furnished shall meet the requirements specified in Chapter 12 of the Type 170E Traffic Signal Control Hardware Specification, FHWA IP-78-16, as currently amended except as modified by the following:

1. Cabinets shall be fabricated of 0.125-inch sheet aluminum, 5052 alloy, with mill finish, in accordance with Section 9-29.13(7)D, Item number 1. Painted or anodized aluminum is not allowed.

2. Cabinet doors shall have a three-point latch and two-position stop assembly with spring loaded construction core lock capable of accepting a Best Lock Company 6-pin CX series core. The Design-Builder shall supply green construction cores. Upon contract completion, the Design-Builder shall deliver two master keys to WSDOT.

3. Field wire terminals shall be labeled in accordance with the ITS Field Wiring Chart.

Cabinet Ventilation and Heating
A disposable paper filter element of at least 185 square inches shall be provided in lieu of a metal filter.

The cabinet shall be equipped with an electric strip heater with a rating of 100 watts and 120 VAC, and a ventilation fan meeting the requirements specified in Chapter 12 of FHWA IP-78-16. The strip heater shall be shielded in a manner that prevents damage to nearby electrical cables.

The fan and strip heater shall be controlled by a high-low adjustable thermostat that can be set to ensure the cabinet interior temperature remains between 60°F and 125°F

Cabinet Accessories
The Design-Builder shall provide all cabinet accessories, including:

1. Two shatterproof fluorescent interior cabinet lights with self-starting ballast shall be furnished, one fixture mounted on the rear rack near the top and the second mounted at the top of the front rack. Door switches shall automatically turn on both lights when either door is opened.

2. One controller unit shelf, which attaches to the front rails of the EIA rack, shall be provided in lieu of the two controller unit support angles. The shelf shall be fabricated from aluminum and shall be installed such that it does not interfere with access to any terminal block. The shelf shall contain a roll-out flip-top drawer for storage of wiring diagrams and manuals.

3. Each Model 334 cabinet shall be equipped with a fully operable Type 170E controller equipped as specified in these Special Provisions.

4. A transient voltage protection device shall be provided, which plugs into the controller unit receptacle and in turn accepts the controller plug and meets the electrical requirements of Section 9-29.13(7)B(3)e.

5. The cabinet shall be equipped with a power distribution panel mounted on a standard EIA 19-inch (ANSI/EIA RS-310-C) rack utilizing no more than five rack-mounted spaces (8.75 inches). The following devices shall be provided with the power distribution panel:

    a. Duplex 120 VAC power receptacle.
    b. Main circuit breaker, 120 VAC, 20 amp.
    c. Four load circuit breakers, 120 VAC, 15 amp.
    d. Neutral bus
    e. Ground Bus
    f. Surge suppresser and filter unit 120 VAC, 50 amp.

    Power distribution panel components shall be mounted in or on the panel such that they are readily accessible, provide dead front safety, and all hazardous voltage points are covered to prevent inadvertent contact.

6. Each Cabinet shall be furnished with a mounted panel. The mounting panel shall be fabricated foam backed aluminum and shall be 19 inches wide by 10 inches tall.

7. The mounting panel shall be equipped with one HAR sign control switch with labels and functions as follows:

AUTOMATIC
Flashing Beacons shall energize upon ground true call from controller.

SIGN OFF
Flashing Beacons shall de-energize.

SIGN ON
Flashing Beacons shall energize.

8. The sign relay shall be plugged into a socket installed on the rear of the mounting panel. The relay shall be wired per WSDOT standards. The relay coil shall draw (or sink) less than 50 milliamperes from the 170E controller and have a DPDT contact rating not less than 10 amperes. A 1N4004 diode shall be placed across the relay coil to suppress voltage spikes.

9. The Design-Builder shall design and install the C1 connector according to the pin assignments as designed per WSDOT standards .

10. One reproducible drafting film and two non-fading copies of the cabinet wiring diagram shall be furnished with each cabinet.

11. Each HAR sign cabinet shall be supplied with one Model 204 sign flasher unit mounted on the right rear side panel.

12. The Design-Builder shall design, provide and install a rack-mounted fiber optic patch panel.

13. The Design-Builder shall provide and install on the mounting panel, a standalone fiber optic modem as specified in these Special Provisions. The Design-Builder shall also provide and install the cable between the fiber optic modem and the C-2 plug of the model 170E controller.

Cabinet Wiring

1. Cabinet wiring shall conform to the details and diagrams in the Standard Plans. The Design-Builder shall trim wiring to eliminate all slack and lace or bind together with nylon wraps or equal. All terminals shall be labeled. The cabinet shall be wired completely so that the only requirement to make a field location completely operational is to connect field, power and ground wires to appropriate terminals.

2. Terminal block TB1 shall be installed in the cabinet.

   Terminals for field wiring shall be labeled, numbered and connected in accordance with the following:

Terminal Block Pos.	Terminal and Wire Numbers	Connection Identification
TBS	501-502	AC Power, Neutral
TB1-1	644	Flasher Output NC
TB1-2	645	Flasher Output NO

TB1-3 Future Neutral

Model 170E Controller

Each controller unit furnished shall meet the requirements specified in the Type 170E Traffic Signal Control Hardware Specification, FHWA IP-78-16, as currently amended and modified as follows:

1. The 170E CPU module shall operate a 68HC11F1 MPU at a crystal frequency of 8MHz. The MPU shall be socket mounted in a PLCC socket.

2. The EPROM shall be resident on the CPU module. The EPROM socket shall be a 32-pin lever-controlled ZIF device. The EPROM shall be either a 32K x 8 or a 128K x 8 device. The device size shall be jumper selectable.

3. Feature and Location switches shall be provided on the front portion of the CPU module. Each switch shall be an 8-position front-reading dip switch. The switches shall be addressed as follows:

   Location Switch at 7000 (Port A)
   Feature Switch at 700A (Port E)

4. There shall be one LED indicator located on the front of the CPU module. This LED shall be connected to bit 3 of Port G.

5. The 170E controller shall have a minimum of 28 kB of battery backed static RAM on the CPU module. RAM shall be continuous from location 0000 to 6FFF.

6. Four Asynchronous Communication Interface Adapters (ACIAs) shall be provided on the same board as the CPU. The ACIAs shall be 6850 ICs operating at a crystal frequency of 6.144MHz. Each ACIA shall have 5 programmable jumpers to select 5 communication baud rates (1200, 2400, 4800, 9600, 19200) for a total of 20 jumpers. All ACIAs shall be active. An IRQ status register shall be provided at 75FF.

7. The Model 412C PROM module shall not be provided. A blank panel shall cover the PROM slot.

8. Two blank 27256 EPROM chips shall be provided with the CPU module.

9. Each controller shall have an ACIA C20 wrap-around with the following pin connections:

C20 Function Pin		C20 Function Pin	
(J) RTS	to	(M)	CTS
(J) RTS	to	(H)	DCD
(K) DATA-IN	to	(L) DATA-OUT	

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10. Each 170E controller shall include a Model 400 modem.

Construction Requirements

Section 8-20.3 is supplemented with the following:

Sign Assembly
Mounting shall be as shown in the Plans.

Flashing Beacons
The beacons shall be installed as shown in the detail in the Plans. The flasher units shall be housed within the sign control cabinet.

Sign Lighting Luminaire
The luminaires shall be installed as shown in the Plans.

Sign Control Cabinet
The control cabinet shall be wired and installed as shown in the Plans.

Testing
The Design-Builder shall demonstrate that upon command from the TSMC the beacons and sign lights can be activated.
(******)
Warranty
In addition to the requirements of Section 1-05.10 **Guarantees**, the Design-Builder shall provide a one-year (minimum) manufacturer's warranty for major components of the HARS system. These warranties shall be written by the manufacturer or authorized repair agent of said equipment and shall include parts and labor and return freight or shipping. The warranty shall name Washington State DOT Northwest Region Signal Maintenance Superintendent as the equipment owner. The warranty shall cover defects in material and workmanship under normal use. The State will be responsible for items damaged due to accidents, acts of God, misuse, negligence by the State, or by a third party. The following components shall be provided with a warranty:

Controller
Flashing beacons
Sign lighting luminaries
HARS cabinet accessories

The Design-Builder shall coordinate the warranty period with the manufacturer, or authorized repair agent of said equipment, to begin upon acceptance of the system. Acceptance of the system is defined as starting on the physical completion date of the contract or, if relief of responsibility is to be granted in accordance with Section 1-07.13(2), on the date WSDOT relieves the Design-Builder from responsibility for the completed system.

The Design-Builder shall provide WSDOT with a written copy of all manufacturers' warranties for the HARS system. The warranty document shall denote that the warranty period begins upon acceptance of the system and not on product delivery.

Communication Conduit System

Description

Section 8-20.1 is supplemented with the following:

This work shall consist of furnishing and installing the facilities used to mechanically accommodate the communication components of the ITS System. The Design-Builder shall be responsible for interfacing with the

existing communications system and satisfying system compatibility with regard to the existing facilities and this communications system extension. Conduit shall be supplied as a system from a single manufacturer providing all of the steel and PVC conduit; all required fittings, terminations, and other installation accessories; all in accordance with the Plans, the Standard Specifications and these Special Provisions.

Materials

Section 9-29 is supplemented with the following:

4 inch PVC Schedule 40 and Schedule 80 Conduit With Innerduct

The conduit shall be free from defects, including non-circularity, foreign inclusions, etc. It shall be uniform in color, density, and physical properties. It shall be straight and the ends shall be cut square to the inside diameter. All conduit shall display the Underwriters Laboratory certification (UL Listed). All conduit shall continue to meet the requirements of Section 9-29.1 unless specified otherwise herein.

Fiber Optic Cable

The fiber optic cable network shall be capable of supporting both SONET transmission speeds and protocols up to 2.4 Gb/s, and NTSC quality, color video applications.

The Design-Builder shall provide manufacturer's certification that the submitted cable shall comply with the Rural Utilities Service (RUS) Specification 1755.900 as currently amended and with the requirements set forth in this Special Provision. Any deviations from these specifications shall be conspicuously noted in the Design-Builder's submittal.

Each cable shall contain the total number of optical fibers as specified in the Plans. For all cables with a strand count greater than 36, the fibers shall be placed in loose buffer tubes in groups of 12. For all other cables, the fibers shall be placed in loose buffer tubes in groups of 6.

Section 9-29.3(1) is supplemented with the following:

Typical Core Diameter: 8.3 microns
Cladding Diameter: 125.0 microns +/- 1.0 micron

Flexible bends shall be supplied in the minimum lengths necessary to meet field requirements.

Location Wire and Warning Tape

Warning Tape

Warning tape shall be polyethylene. The polyethylene shall have a minimum 4 mil thickness and be 3 inch wide. The polyethylene shall be orange in color and printed in black with the words "Fiber Optic Cable Buried Below."

Location Wire

Location wire shall be #14 AWG THWN or XHHW orange-colored wire.

Cable Vaults and Pull Boxes
Cable vaults and pull boxes shall meet AASHTO M-199, H-20 or H-35 loading requirements. Cable vaults and pull boxes installed in paved shoulders or lanes that will be subjected to vehicular traffic during any phase of this contract or as specified in the Plans shall meet H-35 loading requirements. Cable vaults and pull boxes shall be fabricated in accordance with ASTM C857-83 and C858-83. All cable vaults and pull boxes shall include the following provisions:

1. A sump 6 inches in diameter by 2 inches in depth with a 1 inch diameter drain hole in the center of the sump.

2. Cable pulling irons positioned to afford bi-directional cable installation through the cable vault or pull box.

3. Factory installed knock-outs for conduit entry.

4. All cable racking hardware shall be stainless steel.

5. Cable vaults meeting H-20 requirements shall have a hinged and spring-assisted double steel plate cover. Cable vaults and pull boxes meeting H-35 requirements shall have round cast iron lids. Pull boxes meeting H-20 requirements shall have a hinged, single plate cover. All cable vault and pull box covers shall be marked with ITS legend according to Standard Plan J-11a.

Above ground pull boxes shall be a minimum 16 inches wide, 16 inches high and 8 inches deep, unless otherwise specified in the Plans. Above-ground boxes shall be fabricated in accordance with NEMA 4X designation for stainless steel enclosures. Pull boxes shall be equipped with a removable front panel for access to all conduits. The front panel shall be hinged and the entire pull box shall be fabricated from stainless steel.

Controlled-density Fill
Controlled-density fill (CDF) shall be in accordance with Section 2-09.2 and Section 2-09.3(1)E. CDF shall be tinted orange.

Construction Requirements
Section 8-20.3 is supplemented with the following:

Submittals
Within a minimum of 30 calendar days prior to anticipated construction, the Design-Builder shall provide all documentation pertaining to the materials and method of execution proposed to satisfy the requirements of this section. WSDOT's approval is required prior to the committing of any materials or the commencement of any work.

The Design-Builder shall anticipate a minimum of 30 calendar days for approval or disapproval of each submitted item. Actual time for WSDOT's review is dependent upon the completeness and appropriateness of the documentation being submitted. Any deficiencies will require additional time for approval. Any delays caused by such deficiencies will not be considered grounds for

extension of project time. The Design-Builder shall anticipate review intervals to ensure project progress in accordance with Section 1-08.3.

WSDOT's approval of any submitted documentation shall in no way relieve the Design-Builder from compliance with the safety and performance requirements as specified herein.

Submittals required by this item shall include, but not be limited to, the following:

1. The manufacturer's specifications for cable vaults and pull boxes.
2. Detailed shop drawings of pull box and cable vault fabrication.
3. Manufacturer's specifications for all conduit, fittings and accessories.
4. Three foot sample of each type (PVC schedule 40 and PVC schedule 80) of conduit with bell ends and one sample of each item listed in the subsection **Accessory Hardware**.
5. Certificate of compliance with requirements for coefficient of friction and Bellcore GR-356-CORE for innerducts.

Location Wire and Warning Tape

Warning Tape

Warning tape shall be installed in continuous sections for all underground fiber optic conduit installation where trenching is required. The warning tape shall be installed approximately 6 inches below the surface of pavement or existing grade. Warning tape shall be installed a minimum of 12 inches into all cable vaults and pull boxes at both ends of the trench.

Location Wire

Wire conductor shall be installed in continuous sections for all underground fiber optic conduit installation where trenching is required. A minimum of 6 feet of location wire shall be extended into each cable vault or pull box. The locate wire shall be attached to the "C" channel or the cover hinge bracket with stainless steel bolts and straps. A 1-foot loop of locate wire shall be provided above the channel as shown in the Plans. Locator wire shall be placed between the conduits in dual conduit installations or on top of conduits for single conduit installations.

Communication Cables And Interfaces

Description

Section 8-20.1 is supplemented with the following:

This work shall consist of furnishing, installing and testing all materials and equipment necessary to complete in place the communication cable and interface system and, when specified, the modification of such an existing system.

Materials

Section 9-29 is supplemented with the following:

Quality Assurance
All materials described in this Section shall meet or exceed the applicable provisions of the following documents:

1. CFR 1755.900, RUS Specification for Filled Fiber Optic Cables
2. ANSI, C8.47-1983, American National Standard for Polyolefin-insulated Thermoplastic Jacketed Communication Cables
3. EIA-455-27A, Method of Measuring (Uncoated) Diameter of Optical Waveguide Fibers
4. EIA-455-28B, Method For Measuring Tensile Failure Point of Optical Waveguide Fibers
5. EIA-455-34, Interconnection Device Insertion Loss Test
6. EIA-455-95, Absolute Optical Power Test for Optical Fibers and Cables
7. EIA-455-103, Buffered Fiber Bend Test
8. EIA-598-A-1, Special Colors for fiber optic cordage
9. EIA-598-B, Color Standard for Optical Fibers

Cables shall be of loose tube design. The tubes shall be surrounded by a dry, moisture-blocking filling compound surrounding the fibers.

The cable shall be constructed with the following components:

1. A dielectric central strength member
2. Buffer tubes containing optical fibers
3. Aramid (Kevlar) yarn
4. Outer MDPE jacket

Cables
The Design-Builder shall provide all materials required for the installation and splicing of the specified communications cables, power cables and associated interface devices.

The Design-Builder shall provide an unconditional warranty on all installed cable for a period of one (1) year.

At the request of WSDOT, the Design-Builder shall submit a 3-foot sample cable section to WSDOT for approval for each type of cable to be provided.

Fiber Optic Cable
The fiber optic cable network shall be capable of supporting both SONET transmission speeds and protocols up to 2.4 Gb/s, and NTSC quality, color video applications.

The Design-Builder shall provide manufacturer's certification that the submitted cable shall comply with the Rural Utilities Service (RUS) Specification 1755.900 as currently amended and with the requirements set forth in this Special Provision. Any deviations from these specifications shall be conspicuously noted in the Design-Builder's submittal.

Each cable shall contain the total number of optical fibers as specified in the Plans. For all cables with a strand count greater than 36, the fibers shall be placed in loose buffer tubes in groups of 12. For all other cables, the fibers shall be placed in loose buffer tubes in groups of 6.

Section 9-29.3(1) is supplemented with the following:

Typical Core Diameter: 8.3 microns
Cladding Diameter: 125.0 microns +/- 1.0 micron

Multimode Optical Fibers
All multimode optical fiber cable shall be of a loose tube buffer design and of industry standard construction for underground conduit installations as well as of an all dielectric construction.

Each optical fiber shall be fabricated from 100 K PSI glass and shall meet this specification.

The multimode fibers shall have a nominal core diameter of 62.5 microns, with no variation greater than 3 microns. The non circularity of the core surface shall be less than 6 percent. Core non circularity is defined as the difference between the longest and shortest chords each passing through the center of the core and connecting on the core/cladding interface, divided by the average core diameter. Optical fiber dimensions shall be in compliance with the methods for measuring as established in EIA-STD, 455-176.

The multimode cladding shall have a nominal outside diameter of 125 microns with no variation greater than 3 microns. Non circularity of the cladding surface shall be less than 4 percent. Cladding non circularity is defined as the difference between the longest and shortest chords, each passing through the center of the cladding and connecting points on the outer cladding surface, divided by the average diameter of the cladding surface.

The concentricity error for multimode optical fibers shall be less than 6 percent, where the error is the distance between the core and cladding centers divided by the average core diameter.

The coated multimode optical fibers shall have a nominal outside diameter of 250 microns, with no variation greater than 15 microns and a minimum coating thickness of 50 microns.

Fibers shall contain no factory splices.

The maximum attenuation of each 62.5/125 multimode fiber at the temperature range of -40°C. to +70°C. shall be no greater than 1.00 dB/km at 1310 nm nominal. The information transmission capacity (bandwidth) for each multimode optical fiber shall be 500 MHz-km. The attenuation shall be measured on a completed reel length of cable then normalized to a length of 1 km. The measurement method shall be in accordance with the manufacturer's recommended procedure.

All fibers shall be free from imperfections and inclusions that would prevent them from meeting the transmission and mechanical requirements of this specification. Anomalies shall not exceed 0.20 dB.

The maximum dispersion at 68°F. shall be 2.6 ps/nm-km over the range of 1225 to 1330 nm.

The cutoff wavelength shall be 1200 nm nominal, and shall have no variation greater than 70 microns.

Optical Performance
The optical performance shall meet the requirements of the specifications.

Design-Builder shall warrant that the installed cable shall provide an absolute maximum attenuation of no greater than 3.0 dB/km at 850 nm nominal and 1.0 dB at 1300 nm nominal for each 62.5/125 multimode fiber at the temperature range of -40°C. to +70°C. The attenuation of multimode fibers shall be determined by EIA-STD-455-46.

The information transmission capacity (bandwidth) of each multimode optical fiber shall be 500 MHz_km. The information capacity of each fiber shall be measured in the time domain environment and the result shall be expressed in terms of _3 dB (optical power) frequency. The method to determine the pulse distortion shall be EIA,-STD-455-51.

Interfaces

Fiber Optic Patch Panels
The fiber optic patch panel shall be rated by the manufacturer as a fiber optic patch panel. The patch panel shall be designed to hold, at a minimum, the specified number of interconnection sleeves and splice trays. The splice trays and the fiber optic interconnection sleeves shall be fully enclosed on all sides by the patch panel when the patch panel is closed.

Each patch panel shall be fully populated with interconnection sleeves. Interconnection sleeves shall contain zirconium (ceramic) linings (phosphorus bronze is not allowed). All unutilized interconnection sleeves shall have protective dust covers installed.

The patch panels shall be 19-inch (ANSI/EIA RS-310-C) rack-mountable, unless otherwise noted.

Mounting plates for interconnection sleeves shall be constructed of metal. Adequate spacing shall be provided around each interconnection sleeve. Where interconnection sleeves are arranged in a vertical line, the minimum horizontal center-to-center spacing shall be 1.25 inches (31mm), and the minimum vertical center-to-center spacing shall be 0.625 inches (16mm). Where interconnection sleeves are arranged in a staggered layout, the minimum center-to-center radial distance between sleeves shall be 0.875 inches (22mm).

A wiring diagram shall be supplied with each patch panel. The wiring diagram shall identify each fiber terminated in the patch panel using the fiber optic cable labeling method as specified later in these provisions. The wiring diagram shall be placed in a plastic sheet protector next to the patch panel.

Small Cabinet Fiber Optic Patch Panel
The fiber optic patch panel shall be designed to hold a minimum of 6 FC fiber optic interconnection sleeves and splice trays with 12-splice capacity. The patch panel shall allow for full access to the splice trays and both sides of the fiber optic interconnection sleeves from the front of the patch panel. The patch panel shall not exceed 6 inches width, 7.5 inches in height and 2 inches in depth. (Not 19-inch rack-mountable)

Cabinet Fiber Optic Patch Panel
The fiber optic patch panel shall be designed to hold a minimum of 36 FC fiber optic interconnection sleeves and splice trays with 48-splice capacity. The patch panel shall allow for full access to the splice trays and both sides of the fiber optic interconnection sleeves from the front of the patch panel. The patch panel shall not exceed 3 RMU (5.25 inches) in height.

Fiber Optic Hub Patch Panel
The fiber optic patch panel shall be designed to hold a minimum of 144 FC fiber optic interconnection sleeves and splice trays with 144-splice capacity. The patch panel shall have front and back doors to allow for full access to the splice trays and both sides of the fiber optic interconnection sleeves.

Fiber Optic Connector
Unless otherwise noted in the Plans, all fiber optic connectors used on this project shall meet the following:

All shall be FC/UPC
All shall be factory-connectorized

Fiber Optic Cable Lubricant
Fiber optic cable lubricant shall be as follows:

Compatible with the cable jacket
Non-combustible
Water-based leaving little or no residue

Fiber Optic Cable Splicing
Field splices for mainline to lateral cables and for end-to-end mainline cables shall be located as shown in the plans. No additional splices shall be allowed without the approval of WSDOT.

The Design-Builder shall provide all required brackets and other racking hardware required for the fiber optic cable racking operations as specified.

All fusion splicing equipment shall be in good working order, properly calibrated, and meeting all industry standards and safety regulations. Splices shall utilize two half shells bolted together with stainless steel bolts and be fitted with a neoprene gasket. Selected splices shall not require a re-entry kit. Cable preparation, closure installation and splicing shall be accomplished in accordance with accepted and approved industry standards.

Upon completion of the splicing operation, all waste material shall be deposited in suitable containers for fiber optic disposal, removed from the job site, and disposed of in an environmentally acceptable manner.

The Design-Builder shall use the fusion method with local injection and detection for all fiber optic splicing.

The average splice loss of each fiber shall be 0.15 dB or less per splice. The average splice loss is defined as the summation of the attenuation as measured in both directions through the fusion splice, divided in half.

No individual splice loss measured in a single direction shall exceed 0.20 dB.

The Design-Builder shall seal all cables where the cable jacket is removed. The cable shall be sealed per the cable manufacturer's recommendation with an approved blocking material.

All below ground splices shall be contained in waterproof splice closures.

All splices shall be contained in splice trays utilizing strain relief, such as heat shrink wraps, as recommended by the splice tray manufacturer.

Upon sealing the splice closure, the Design-Builder shall show that the closure maintains 10 psi of pressure for a 24-hour period.

Copper Cable Protector Block
Copper cable protector blocks shall have the following:

1. A combination connection/protector stubless, with bifurcated quick-clip terminals block for the protection and termination of an OSP cable.

2. Twenty-five solid state type protector units, with gold pins, for the low voltage heat coil.

3. Type R66B 25-pair 6-position quick connect terminal blocks shall be installed; one for the TWP cable and one for every three 6-TWP lateral cables terminating in the cabinet. One more shall be mounted on a backboard in the cabinet.

    a. Each block shall contain 50 rows with six clips each.

    b. Each row shall be clearly and permanently marked with the number of the cable pair which is attached.

    c. Within each row the clips shall be electrically connected within the block so as to form two sets of three adjacent clips.

Copper Cable Termination Blocks
Copper cable termination block units shall have 25-pair bifurcated quick clip termination blocks.

Terminal Cabinets
Terminal cabinets furnished for this contract shall be pad mounted and fabricated in accordance with Section 9-29.25 except:

1. Cabinets shall be fabricated of 0.125” sheet aluminum, 5052 alloy, with mill finish, in accordance with Section 9-29.13(7)D, Item number 1. Painted or anodized aluminum is not allowed.

2. Cabinet doors shall be two-hinged with neoprene gasket and provided with a three-point latch and two-position stop assembly with spring loaded construction core lock capable of accepting a Best Lock Company 6-pin CX series core. The Design-Builder shall supply green construction cores with two master keys and one core key per lock. The Design-Builder shall deliver the keys to WSDOT.

3. The termination block shall provide on Type R66B 25-pair stubless bifurcated quick-clip terminal for each 25 TWP cable and one for every three 6 TWP lateral cables terminated in the cabinet. One more quick clip terminal shall be installed on a backboard in the cabinet.

Fiber Optic Terminal Cabinets
Fiber Optic terminal cabinets furnished for this contract shall be pad mounted have the same external physical dimensions and appearance of Model 334 cabinets, and fabricated in accordance with Section 9-29.25 except:

1. Cabinets shall be fabricated of 0.125” sheet aluminum, 5052 alloy, with mill finish, in accordance with Section 9-29.13(7)D, Item number 1. Painted or anodized aluminum is not allowed.

2. Cabinet doors shall have a three-point latch and two-position stop assembly with spring loaded construction core lock capable of accepting a Best Lock Company 6-pin CX series core. The Design-Builder shall supply green construction cores. Upon contract completion, the Design-Builder shall deliver two master keys to WSDOT.

3. The cabinet shall be equipped with an electric strip heater with a rating of 100 watts and 120 VAC and a ventilation fan meeting the requirements specified in Chapter 12 of FHWA IP-78-16.

   The fan and strip heater shall be controlled by a high-low adjustable thermostat that can be set to ensure the cabinet interior temperature remains between 60°F and 125°F. The heater strip shall be shielded.

4. Two shatterproof fluorescent interior cabinet lights with self-starting ballast shall be furnished, one fixture mounted on the rear rack near the top and the second mounted at the top of the front rack. Door switches shall automatically turn on both lights when either door is opened.

5. The cabinet shall be equipped with a power distribution panel mounted on a standard EIA 19 inches rack utilizing no more than five rack mounting spaces (8.66 inches). The following devices shall be provided with the power distribution panel:

   a. Duplex 120 VAC power receptacle.

   b. Main circuit breaker, 120 VAC, 50 amp.

   c. Four load circuit breakers, 120 VAC, 15 amp.

d. Neutral bus.

f. Ground bus.

g. Surge suppresser and filter unit, 120 VAC, 50 amp.

Power distribution panel components shall be mounted in or on the panel such that they are readily accessible, provide dead front safety, and all hazardous voltage points are covered to prevent inadvertent contact.

6. One controller unit shelf, which attaches to the front of rails of the EIA rack, shall be provided. The shelf shall be fabricated from aluminum and shall contain a roll-out flip-top drawer for storage of wiring diagrams and manuals.

7. The Design-Builder shall provide and install a rack-mounted fiber optic patch panel as identified in the Plans.

Construction Requirements

Section 8-20.3 is supplemented with the following:

Submittals

Within a minimum of 30 calendar days prior to anticipated construction, the Design-Builder shall provide all documentation pertaining to the materials and method of execution proposed to satisfy the requirements of this section. WSDOT's approval is required prior to the committing of any materials or the commencement of any work.

WSDOT shall either approve or disapprove each submitted item within 30 calendar days of submittal subject to the completeness of the Design-Builder's submittal. Actual elapsed time for WSDOT's review is dependent upon the completeness and appropriateness of the documentation being submitted. Any deficiencies in the Design-Builder's submittals shall require additional time for approval. Any delays caused by such deficiencies shall not be grounds for extension of project consideration dates. The Design-Builder shall anticipate review intervals and schedule submittals accordingly to ensure project progress in accordance with Section 1-08.3.

WSDOT's approval of any submitted documentation shall in no way relieve the Design-Builder from compliance with the safety and performance requirements as specified herein.

Submittals required by this item shall include, but not be limited to, the following:

1. A material staging plan, should the Design-Builder propose State owned property as a staging area.

2. Manufacturer's complete specifications for all communication system cables and, associated electronics and hardware components.

3. Manufacturer's complete specifications for twisted-pair cable splice enclosures.

4. A detailed fiber optic and twisted-pair cable installation procedure including the following:

a. Fiber optic cable cutting lengths reflecting the cable order and reel allocations.

b. Cable pulling plan which shall state the exact operational procedures to be utilized and which identifies the physical locations for equipment placement, proposed equipment setup at each location, pulling tension on all cables for each pull, staffing, and the pulling methodology for each type of cable.

c. Exact splice points as provided for herein.

d. Workforce proposed for all equipment, safety, and manual assist operations

5. Factory test data sheets for each reel of cable delivered.

Cable Installation - General

The Design-Builder shall determine a suitable cable installation method to ensure that all cable installation requirements shall be met in all conduit sections. All work shall be carried out in accordance and consistent with the highest standards of quality and craftsmanship in the communication industry with regard to the electrical and mechanical integrity of the connections; the finished appearance of the installation; as well as the accuracy and completeness of the documentation.

The Design-Builder shall make a physical survey of the project site for the purpose of establishing the exact cable routing and cutting lengths prior to the commencement of any fiber optic work or committing any fiber optic materials. Splicing is only allowed for the programmed connection of reels and as shown in the Plans to connect a lateral fiber optic cable to the mainline distribution fiber optic cable. The Design-Builder shall submit a cable routing plan that shows the locations of all splices. All splice locations must be approved by WSDOT.

All work areas shall be clean and orderly at the completion of work and at times required by WSDOT during the progress of work.

Fiber Optic Cable Installation

Fiber optic cables shall be installed in continuous lengths without intermediate splices throughout the project, except at the location(s) specified in the Plans, or as approved in writing by WSDOT.

The Design-Builder shall comply with the cable manufacturer's specifications and recommended procedures including, but not limited to the following:

1. Installation.
2. Proper attachment to the cable strength elements for pulling during installation.
3. Bi-directional pulling.
4. Cable tensile limitations and the tension monitoring procedure.
5. Cable bending radius limitations.

The Design-Builder shall protect the loops from tangling or kinking. At no time during the length of the project shall the cable’s minimum bending radius specification be violated.

To accommodate long, continuous installation lengths, bi-directional pulling of the fiber optic cable shall be permitted.

In all cable vaults, pull boxes, and at all splice locations cable slack of 50 feet shall be left by the Design-Builder, unless otherwise specified in the Plans. The 50 feet length of fiber optic cable shall be coiled and secured with tie raps to racking hardware or as specified in the Plans.

Installation shall involve the placement of fiber optic cables in a specified inner duct as defined in the Plans. The Design-Builder shall ensure that inner ducts are secured to prevent movement during the cable installation process.

The pulling eye/sheath termination hardware on the fiber optic cables shall not be pulled over any sheave blocks.

When power equipment is used to install fiber optic cabling, the pulling speed shall not exceed 100 feet per minute. The pulling tension limitation for fiber optic cables shall not be exceeded under any circumstances.

Large diameter wheels, pulling sheaves, and cable guides shall be used to maintain the appropriate bending radius. Tension monitoring shall be accomplished using commercial dynamometers or load-cell instruments.

Patch cords, placed between pad mounted cabinets, shall be protected by plastic spiral wrapping. Spiral wrap shall cover the entire length of the patch cord(s) to within 12 inches of end. The spiral wrap shall be installed before the patch cords are pulled into the conduit(s) and be rated for use in electrical installations.

Fiber optic cable lubricant shall be used to reduce pulling tensions for the installation of each fiber optic cable.

Fiber Optic Cable Splicing

Field splices for mainline to lateral cables and for end-to-end mainline cables shall be located as shown in the plans. No additional splices shall be allowed without the approval of WSDOT.

The Design-Builder shall provide all required brackets and other racking hardware required for the fiber optic cable racking operations as specified.

All fusion splicing equipment shall be in good working order, properly calibrated, and meeting all industry standards and safety regulations. Splices shall utilize two half shells bolted together with stainless steel bolts and be fitted with a neoprene gasket. Selected splices shall not require a re-entry kit. Cable preparation, closure installation and splicing shall be accomplished in accordance with accepted and approved industry standards.

Upon completion of the splicing operation, all waste material shall be deposited in suitable containers for fiber optic disposal, removed from the job site, and disposed of in an environmentally acceptable manner.

The Design-Builder shall use the fusion method with local injection and detection for all fiber optic splicing.

The average splice loss of each fiber shall be 0.15 dB or less per splice. The average splice loss is defined as the summation of the attenuation as measured in both directions through the fusion splice, divided in half.

No individual splice loss measured in a single direction shall exceed 0.20 dB.

The Design-Builder shall seal all cables where the cable jacket is removed. The cable shall be sealed per the cable manufacturer's recommendation with an approved blocking material.

All below ground splices shall be contained in waterproof splice closures.

All splices shall be contained in splice trays utilizing strain relief, such as heat shrink wraps, as recommended by the splice tray manufacturer.

Upon sealing the splice closure, the Design-Builder shall show that the closure maintains 10 psi of pressure for a 24-hour period.

Fiber Optic Cable Labeling
Permanent cable labels shall be used to identify fibers and patch cords at each termination point. The cable labels shall consist of white colored heat shrink wraps with identification based on the schematic shown on the ITS detail sheets.

Twisted-Pair Copper Cable Installation
The Design-Builder shall install all OSP cables and associated terminal blocks.

Cables shall be terminated in the communication hubs on a combination connector/protector block, which shall be an AT&T Type 310 bifurcated quick clip terminal block mounted on the wall of the vault. Protection shall be provided for each pair. The surge protector shall be solid state, low voltage (60-90 volts) for non-ringing circuits and shall have a heat coil for sneak current protection, and gold-plated pins. Protector block ground shall be connected to the ground bus.

Where cables are terminated at terminal blocks in cabinets, the same pair assignment shall be maintained.

Cable Racking in Pull Boxes and Cable Vaults
The Design-Builder shall rack the cable in vertical figure eight loops, which shall permit pulling slack from the vaults without introducing twist to the cable.

Cables shall be secured in racked positions with nylon ties. Identification or warning tags shall be securely attached to the cables in at least two locations in each pull box or cable vault.

All coiled cable shall be protected to prevent damage to the cable and fibers. Racking shall include securing cables to brackets (racking hardware) that extend from the side walls of the pull box.

All racking hardware shall be stainless steel.

As-Built Records
The Design-Builder shall provide WSDOT with a cable route diagram indicating the actual cable route and "meter marks" for all intersections, directional change points in the cable routing, and all termination points. The Design-Builder shall record these points during cable installation. Cable system "as-built" drawings showing the exact cable route shall be provided by the Design-Builder to WSDOT. All ITS equipment locations shall be included. Information such as the location of slack cable and its quantity shall also be recorded in the cable route diagram.

Fiber Optic Cable Testing
The installed optical fiber cable shall be tested for compliance with the transmission requirements of this specification, the cable and hardware manufacturer's specifications, and prescribed industry standards and practices.

Types of Testing
The types of acceptance testing for optical fiber cable system certification are:

Attenuation testing

Optical Time Domain Reflectometer (OTDR) testing

Attenuation Testing
Insertion loss testing shall be used to measure end-to-end attenuation on each new fiber installed between a field device and a communications hub as well as between communications hubs. Insertion loss testing shall be performed at the 1310 nanometer wavelength in both directions.

Prior to commencing testing, the Design-Builder shall submit the manufacturer and model number of the test equipment along with certification that it has been calibrated within 6 months of the proposed test dates.

The following information shall be documented for each fiber test measurement:

Wavelength
Fiber type
Cable, tube and fiber IDs
Near end and far end test locations
End-to-end attenuation
Date, time, and operator

Optical Time Domain Reflectometer (OTDR) Testing
An optical time domain reflectometer (OTDR) with recording capability shall be utilized to test the end-to-end transmission quality of each optical fiber. Quality tests shall consider both attenuation and discontinuities. The OTDR shall be equipped with 1310 nanometer and 1550 nanometer light sources for singlemode optical fibers. The OTDR shall be capable of providing electronic and hard copy records of each test measurement.

The OTDR shall be equipped with sufficient internal masking to allow the entire cable section to be tested. This may be achieved by using an optical fiber pigtail of sufficient length to display the required cable section, or by using an OTDR with sufficient normalization to display the required cable section.

Prior to commencing testing, the Design-Builder shall submit the manufacturer and model number of the OTDR test unit along with certification that it has been calibrated within 6 months of the proposed test dates.

Each new mainline and lateral fiber shall be tested in both directions at the 1310 and 1550 nanometer wavelengths. Existing mainline and lateral fibers that are spliced to or re-spliced as part of this contract shall also be tested in both directions and at both wavelengths.

The following information shall be documented for each fiber test measurement:

X-Y plot scaled for fiber length
Wavelength
Refraction index
Fiber type
Averaging time
Pulse width
Cable and fiber IDs
Near end and far end test locations
Date, time, and operator
Event table that includes: event ID, type, location, loss, and reflection.

Fiber Cable Testing Documentation
The Design-Builder shall submit one hard copy and one electronic copy of the fiber test results to WSDOT for approval. The Design-Builder shall take corrective actions on portions of the fiber installation determined to be out of compliance with these specifications.

Upon acceptance of the cable installation and test results, the Design-Builder shall submit three hard copies and one electronic copy of the fiber test results to WSDOT.

Hard copy submittals shall be bound in 3-ring binders. The electronic submittal shall be on 3.5” floppy disks or a compact disk and include one licensed copy of the applicable OTDR reader program.

The following information shall be included in each test result submittal:

1. Contract number, contract name, Design-Builder name and address.
2. Dates of cable manufacture, installation, and testing.
3. Cable specifications.
4. Location of all splices.
5. OTDR test results.
6. Attenuation test results.

Within 30 days of submitting the test results, the Design-Builder, in the presence of WSDOT, shall re-test a minimum of 5% of the previously tested locations to validate the test results. A 5% sample will be selected randomly from the terminal device locations.

Twisted-Pair (TWP) Copper Cable Testing
The Design-Builder shall perform a Field Acceptance Test on the installed cable. Each pair shall be tested for frequency attenuation between the communication hub and each ITS device. The State will provide a witness

during the tests and the test results shall be documented as prescribed elsewhere in this specification.

Any pairs showing attenuation greater than 2 dB per mile at 1 kHz shall be cause for rejection of the cable. The Design-Builder shall replace any cable failing this test at no additional expense to WSDOT. The Design-Builder shall provide all test equipment necessary to perform the tests.

All pairs of each underground cable shall be tested for continuity, polarity, shorts, grounds, longitudinal balance, and both resistive and impedance losses consistent with the manufacturer's specifications and standard telecommunication industry requirements

Each TWP copper cable intended primarily for data communication applications shall be tested end-to-end from the controlled environment vault cable termination point to the interface at the traffic control device. The transmission test procedure shall include the continuity testing of each pair within each TWP cable from the outlet in the termination panel in the vault to the termination outlet at each device location.

The Design-Builder shall ensure that all individual wires in all TWP cables have been terminated consistent with the wire insulation color to termination pin requirements set forth in this Special Provision.

The Design-Builder shall document the transmission quality test results for 50% of the pairs in each cable of the installed TWP cable and provide documentation for each cable that the cable meets or exceeds the manufacturer's published specifications and otherwise complies with the requirements set forth in this specification for characteristic impedance, longitudinal balance, resistive and impedance losses, and near-end crosstalk.

The Design-Builder shall provide WSDOT with the manufacturer and model number of the test equipment and the equipment calibration procedures to be used prior to conducting all tests.

The Design-Builder shall test each underground cable end-to-end from the controlled-environment vault-termination block to the terminal block at each cable pedestal or other outside plant terminal equipment. The Design-Builder shall provide actual test readings for each of the following items to verify the required transmission criteria:

DC Resistance - The resistance of any conductor in any cable shall not exceed 20 ohms per 1000 feet.

DC Resistance Unbalance - The resistance unbalance between the two conductors of any pair shall not exceed 5%.

Ambient Noise Measurements - The Design-Builder shall measure the ambient noise level in dBm0 to determine the level of noise on each cable being tested. The distant end of the pair being tested should be terminated with a 600-ohm resistor. At the near end, an HP-3551 or equivalent transmission measuring set should be configured for conducting a noise reading test. Cable pairs being sampled shall provide an ambient noise figure of 30 Dbm0 (-60 dBm) or better. The Design-Builder shall record all readings.

Shield Continuity -Test and measurements shall be made to assure that all underground cable shields are continuous from end-to-end. Each shield shall show a resistance of not more than .75 ohms per 1000 feet.

Within 30 days of submitting the test results, the Design-Builder, in the presence of WSDOT, shall re-test a minimum of 5% of the previously tested locations to validate the test results. A 5% sample will be selected randomly from the terminal device locations.

Warranty
In addition to the requirements of Section 1-05.10 **Guarantees**, the Design-Builder shall provide a one-year (minimum) manufacturer's warranty for fiber optic cable. This warranty shall be written by the manufacturer of the fiber optic cable and shall include parts and labor and return freight or shipping. The warranty shall name Washington State DOT Northwest Region Signal Maintenance Superintendent as the owner. The warranty shall cover defects in material and workmanship under normal use. The State will be responsible for items damaged due to accidents, acts of God, misuse, negligence by the State, or by a third party.

The Design-Builder shall coordinate the warranty period with the manufacturer, or authorized repair agent of said equipment, to begin upon acceptance of the system. Acceptance of the system is defined as starting on the physical completion date of the contract or, if relief of responsibility is to be granted in accordance with Section 1-07.13(2), on the date WSDOT relieves the Design-Builder from responsibility for the completed system.

The Design-Builder shall provide WSDOT with a written copy of all manufacturers' warranties for fiber optic cable. The warranty document shall denote that the warranty period begins upon acceptance of the system and not on product delivery.

Video, Voice, & Data Distribution And Transmission Systems

Description
Section 8-20.1 is supplemented with the following:

This work shall consist of furnishing and installing all materials and equipment necessary to complete in place the video, voice, and data distribution and video transmission systems, and when specified, the modification of such existing systems.

Materials
Section 9-29 is supplemented with the following:

If any equipment specified in this section has been superseded by a newer product that is interchangeable, the newer product shall be supplied. If the product is no longer available and has no replacement, the Design-Builder shall propose a different product meeting the same performance and material specifications as the discontinued one.

Distribution System Cabling
The Design-Builder shall provide and install all required equipment interconnection cabling to include T1 cables, data cables, RG-59/U video coaxial cables, power cables, ancillary cables, and connectors as recommended by the equipment vendor at the cabinet locations and at the TMC. Cables shall be of all copper construction.

Video, Voice & Data Distribution Equipment
Video, voice, and data distribution equipment shall be manufactured by Optelecom, Inc.

1. Equipment Model Numbers:

Duplex T1 Tranceiver	9631/T1-LD-FC
Digital Video Transmitter (stand-alone)	9225DT/SM-FC
Digital Video Receiver	9221DR/SM-FC
Analog Video Transmitter - Singlemode	9412T/SM-FC
Analog Video Receiver - Singlemode	9412R/SM-FC
Drop/Insert Data Modem	9522-LD-FC
Network Interface Card	9911
Network Interface Software	9911-GUI
Hub Chassis	9002
Cabinet Chassis	9003-2
Power Supply (for Hub Chassis)	9030A
AC/DC Adapter (for Cabinet Chassis)	9010PS
AC/DC Adapter (for 9225DT)	9014PS

2. Manufacturer Information:

Optelecom Inc.
12920 Cloverleaf Center Dr.
Germantown, MD 20874
Telephone: (301) 444-2200

The modems for each VMS shall be manufactured by GDI Communications LLC.

1. Equipment Model Numbers:

Stand-alone 9600 bps modem	496SA
Rack-mounted 9600 bps modem	496

2. Manufacturer Information:

GDI Communications LLC
280 Interstate 80 West Exit 1
PO Box 1330
Verdi, NV 89439 USA
Telephone: (775) 345-8000
Fax: (775) 345-8010
Support@sgdi.net

Video Transmission System Cabling
The Design-Builder shall provide and install all required equipment interconnection cabling to include video coaxial cables, power cables, ancillary cables, and connectors as recommended by the manufacturer.

The Design-Builder shall provide and install fiber optic patch cords between the fiber optic patch panels and the equipment specified herein.

Video Transmission System Equipment
Video transmission system equipment shall be manufactured by Communication Specialties, Inc.

1. Equipment Model Numbers:

10-channel digital video transmitter	Pure Digital Fiberlink 3132-F-9
10-channel digital video receiver	Pure Digital Fiberlink 3133-F-9

2. Manufacturer Information:

Communication Specialties, Inc.
55 Cabot Court
Hauppauge, NY 11788
Telephone: (631) 273-0404
Fax: (631) 273-1638
www.commspecial.com
info@commspecial.com

EIA -422 Combiner Unit
This contract shall provide and install the EIA-422, 4-wire combiner as shown in the Plans. The combiner shall be manufactured by Vicon, Inc. This Contract shall provide and install cables from the combiner to the Video/data receivers. The combiner shall have one master port and 10 output ports:

1. Equipment Model Numbers:

Combiner: Model V1400X-IDL Intelligent Distribution Line Control

2. Manufacturer Information:

Vicon Industries, Inc.
89 Arkay Drive
Hauppauge, NY 11788

Telephone: (800) 645-9116
or (631) 952-2288
www.vicon-cctv.com

Voice and Data Transmission System Cabling
The Design-Builder shall utilize singlemode fiber optic cable for the transmission medium in this item. The Design-Builder shall provide and install fiber optic patch cords between the fiber optic patch panels and the equipment specified herein.

Voice & Data Transmission System Equipment
The Telco Systems channel bank equipment set forth below shall be used to multiplex and demultiplex voice circuits to and from a standard T1 bit stream of 1.544 Mb/s. Provide DS0 interface cards in the channel bank as shown in the Plans.

1. Equipment Model Numbers:

Channel Bank Shelf	24FC-19-5
DC to DC Power Supply Unit (PSU)	2430-02
Line Interface Unit (LIU)	2412-01
FXS Channel Unit (2-wire)	2443-20-2
FX0 Channel Unit (2-wire)	2445-20-2
AC Power Supply/Ringing Generator Shelf	3100-10-3
AC to DC Power Supply Card	6690-00-3
Ringing Generator	6691-00-2
Sub-rate Data Unit (SRDU)	2471-40

Note: All line interface equipment shall support ESF and B8ZS protocols.

2. Manufacturer:

   Telco Systems, Inc.
   63 Nahatan Street
   Norwood, MA 02062

   Telephone: (781) 551-0300
   or (800) 776-8832
   www.telco.com

EIA –232 Broadcast Unit
The Design-Builder shall provide and install EIA 232 broadcast unit. The broadcast unit shall be manufactured by Black Box, Inc. The broadcast unit shall have one master port and 8 output ports:

1. Equipment Model Numbers:

   8-Line Broadcast DB8/25

2. Manufacturer:

   Black Box, Inc.
   PO Box 12800.
   Pittsburgh, PA 15241
   Telephone: (412) 746-5500

Rack-mounted Color Monitor
The monitor shall be a color video monitor with a 13” or 14” diagonal picture tube. The monitor shall support EIA NTSC standard color composite video signals (1.0 V p-p, 75 Ohm) and have a resolution of at least 400 horizontal lines. The monitor shall include a minimum of two video input ports; one shall be BNC-type for composite video and one shall be 4-pin (Y/C) type for S-Video. The video output port shall be BNC-type for composite video. The monitor shall include a rear panel slide switch that enables video termination of Hi-Z or 75 ohm.

The monitor’s power source shall be 120 VAC +/- 10%, 60Hz.

The monitor dimensions shall not exceed 14”(H) by 18”(D). The monitor shall have a metal casing and be factory-equipped with rack-mounting hardware (EIA 19”). The monitor weight shall not exceed 40 lb.

The Design-Builder shall supply one BNC coaxial patch cord (RG-59U) of sufficient length to connect the monitor to all video sources mounted in the rack.

The monitor shall be manufactured by Sony, JVC, or Philips

Construction Requirements
Section 8-20.3 is supplemented with the following:

The Design-Builder shall provide and install the following:

$$1$$

Documentation
Documentation for each system element shall consist of the manufacturer's name and model number, serial number when available, materials and operating specifications, wiring schematic and parts list, owners manuals, factory service manuals, and procedures for factory testing and system acceptance testing specified elsewhere herein. The Design-Builder shall submit three copies of the documentation specified above prior to the installation of the cable or components described in the submittal. In addition, the Design-Builder shall submit three copies of an overall system wiring schematic and termination chart for the installed TMS elements (operation and maintenance manuals). All documentation for each individual element shall be neatly bound in such a way that the information is secured together and is totally legible without removing the information from the binding. This documentation shall be in addition to any other data, shop drawings, etc. required to be submitted as specified in these Special Provisions.

Warranty
In addition to the requirements of Section 1-05.10 **Guarantees**, the Design-Builder shall provide a one-year (minimum) manufacturer's warranty for major components of the video, voice, & data distribution and transmission system. These warranties shall be written by the manufacturer or authorized repair agent of said equipment and shall include parts and labor and return freight or shipping. The warranty shall name Washington State DOT Northwest Region Signal Maintenance Superintendent as the equipment owner. The warranty shall cover defects in material and workmanship under normal use. The State will be responsible for items damaged due to accidents, acts of God, misuse, negligence by the State, or by a third party. The following components shall be provided with a warranty:

Video, voice, & data distribution equipment
Video transmission tystem tquipment
Video and data transmission system equipment
Combiner unit
Voice & data transmission system equipment
Broadcast unit
Rack mounted color monitor
Cabinet accessories

The Design-Builder shall coordinate the warranty period with the manufacturer, or authorized repair agent of said equipment, to begin upon acceptance of the system. Acceptance of the system is defined as starting on the physical completion date of the contract or, if relief of responsibility is to be granted in accordance with Section 1-07.13(2), on the date WSDOT relieves the Design-Builder from responsibility for the completed system.

The Design-Builder shall provide WSDOT with a written copy of all manufacturers' warranties for the video, voice, & data distribution and transmission system. The warranty document shall denote that the warranty period begins upon acceptance of the system and not on product delivery.

Communications Hub Steel Controlled Environment Vault (SCEV)

Description

Section 8-20.1 is supplemented with the following:

This work shall consist of providing and installing steel controlled environment vault (SCEV), mechanical and environmental system to support the requirements of the housed environments, two 18 inch rack frames, one 23 inch rack frame (6.9 feet in height) and an uninterrupted power supply (UPS) for each underground SCEV.

Materials

Section 9-29 is supplemented with the following:

The Steel Controlled Environment Vault shall be supplied by Utility Structures, Inc.

Manufacturer:

Utility Structures Inc.
P.O. Box 1630
Brookfield, WI 53008-1630
(414) 252-4711

General

It is the intent of these specifications to describe the minimum requirements for an underground, controlled-environment facility to house the system electronics.

The underground vault is to function as an unattended, underground facility with a controlled-environment suitable for the installation of the system equipment and regular, safe inspection and maintenance by operating personnel. Appropriate electrical, mechanical, and environmental systems shall be provided to support the specific equipment installation.

Vault Description

The vault shall be manufactured as a protected steel structure, intended for installation underground. The structure shall essentially be one-piece, welded, ASTM A36 steel construction. To protect the steel shell underground the manufacturer shall employ a field-proven corrosion protection system.

The vault enclosure shall be a structural steel fabrication designed for a minimum of thirty (30) year life. Structural design shall be done in accordance with the American Institute of Steel Construction (AISC) design practices. All steel shall meet ASTM, A36 standards, as a minimum. Fabrication shall be done in accordance with the specification of the Steel Tank Institute (STI).

The vault shall be fabricated of welded heavy gauge steel plate with reinforcing structural members as required to limit deflection to L=1/360. The vault shall

be rectangular with sides perpendicular to the top and bottom. The completed structure shall be designed to provide a smooth finished appearance on the exterior and limit the exposed surface area requiring corrosion protection. All metal vault components are to be protected by a corrosion protection system. The corrosion protection system requirements are described in more detail later in this specification.

Access shall be through an entrance-way which shall be the only portion of the vault visible above ground. A vertical ladder shall be provided within the entrance-way. The entry size shall be nominally 54 inches x 30 inches and provide a clear entry area approximately 30 inches x 24 inches for system equipment components which are field installed. The entrance shall include a heavy-duty locking mechanism controlled by a keyed cylinder lock set for security.

The lock mechanism shall be a Best Lock Company 6-pin CX series, manually operable from within (to avoid entrapment) and key operable from the exterior. The exterior lock cylinder shall be installed in a manner to provide for protection from the weather. The Design-Builder shall supply green construction cores. Upon contract completion, the Design-Builder shall deliver two master keys to WSDOT. The entry hatch shall be counter-balanced for easy opening by one person.

The vault design shall include provisions for anchoring the structure in the soil to counteract the buoyancy effect of any fluid conditions surrounding the vault. The design shall counteract a fluid condition equal to 14 feet of water.

The vault design shall incorporate a separate inner enclosure within the steel outer vault enclosure. The inner enclosure shall include a painted high-gloss finish, white in color, which is well lighted. The interior shall be lined with ¾ inch ACX plywood to provide for attachment to walls and ceiling. The structure design shall incorporate a minimum R-11 insulation value on all surfaces and provide a vapor barrier and a means to prohibit condensation within the interior to control moisture accumulation between the inner and outer walls.

The inner enclosure shall be electrically isolated from the outer steel enclosure for personnel safety and to provide non-grounded equipment mounting facilities.

Any water leakage into the vault could disrupt the system equipment operation. Therefore, the vault design shall minimize any leakage potential, and as an added measure, provide for containment of water in a below-floor sump area. Water containment capacity and monitoring shall be sufficient to provide adequate warning (under normal circumstances) to permit dispatch of personnel to investigate any problem. Sump disposal capacity shall not be less than 450 gallons per hour.

Wall penetrations for system cable entry and/or exit are to be provided as eight (8), 4 inch diameter openings, as shown on the plans. NPT Threaded connections shall be provided on the exterior of the vault for connection to field-

installed PVC conduits. No metallic conduit connections to field conduits shall be permitted. Additional penetrations shall be provided for electrical connections, sump pump discharge, etc. as required. The system cable penetrations shall be located in the end wall opposite the entrance-way. Penetrations shall be sealed prior to shipment of the vault enclosure. The Design-Builder shall provide and install split-seal assemblies (designed to fit around the communications cable assemblies) prior to installation of the system cabling. In addition, a 2-inch opening shall be provided for a GRS power conduit.

The vault shall include a fold-up work table attached to the wall in front of the equipment racks as shown in the plans. The table shall measure 3 feet wide by 2 feet deep.

The vault shall be complete with the necessary electrical and environmental equipment preinstalled to provide a safe, controlled-environment suitable for personnel and the electronic system. Other sections of this specification describe the features and functions of this equipment.

Vault Corrosion Protection

The vault shall be protected against exterior corrosion and guaranteed for such protection for 20 years. The primary protection system employed shall offer substantial protection to the steel shell and provide a secondary (backup) means of protection. The entire protective system shall be capable of providing over 50 years continuous protection to the steel shell.

The protection system shall incorporate a means for testing the system performance and for predicting the effectiveness of the backup system.

The corrosion protection system should be capable of being inspected on-site, prior to burial to insure its integrity, but shall be completely self-activating upon burial. The installing Design-Builder shall make any necessary inspections and take corrective measures prior to installation in the site excavation.

Vault Environmental System

An Environmental Control Panel (ECP) shall be provided to monitor all environmental conditions within the vault and shall control respective equipment to maintain or correct the condition(s) that exist. This panel shall also provide contacts for remote alarm indications.

The vault environmental system shall be capable of maintaining a controlled environment, including the maintenance of interior temperatures within a specified range without the need for mechanical air conditioning equipment. Additionally, the system shall not be solely dependent upon the induction of outside air to accomplish temperature reduction. Therefore, it shall be possible to limit the induction of outside air and still provide for temperature reduction.

The design of the vault shall permit semi-passive cooling of the interior space. At an interior temperature of 95°F the system shall provide a 3500 BTU/hr heat reduction.

The Environmental Control Panel (ECP) shall maintain the interior temperature within the adjustable range of: 65°F (minimum) to 98°F (maximum). Normal temperature and humidity settings shall be as follows:

Function	Std Setting
Heat	+62°F to +63°F
Cooling OFF	0°F to +12°F above heat
Cool	+75°F to +82°F
Emerg. Vent	+90°F to +95°F
High Temp ALARM	+105°F to +125°F
Dehumidify	55% Relative Humidity
High Humidity ALARM	80% Relative Humidity

A minimum 2.5 pint capacity dehumidifier shall be included in the vault. The dehumidifier shall include self-defrost capability. Dehumidification shall be controlled by the ECP.

Accumulated water from dehumidification or condensation within the air intake ductwork shall be removed by an automatic pump with built-in sump, rated at 140gph @ 1 foot of lift. The pump discharge is piped to the exterior of the vault with PVC piping. The ECP shall provide an electrical interlock to inhibit dehumidification upon failure of the pump.

With typical system equipment installed and operating, supplemental heat will normally not be necessary. However, an electric heater, rated at 1500 watts shall be installed to provide heat: (1) during system equipment installation, (2) in the event only a portion of the system equipment is installed initially, (3) for dehumidification, and (4) if service personnel desire additional heat during occupancy or other unusual conditions. The temperature shall be controlled by the ECP. The heating function shall be electrically interlocked with other environmental functions to prohibit heating above a preset temperature limit, and when the entry hatch is open.

A modulated air volume circulation system shall be included within the vault chamber. This internal circulation system shall provide a variable air volume of 600 to 2720 cfm @ 0.5 inch static pressure for the 10 feet wide vault. The environmental control panel shall vary the volume based upon interior temperature over a 70°F band around the set point. Set point shall be variable over a range of 50° to 90°F.

The environmental control system shall (as a minimum) include the following automatic operations:

a. Immediately upon opening the entrance hatch, the ventilation system shall begin a five (5) minute air purging operation to ensure personnel safety. During the purging operation personnel shall receive a flashing-red visual signal at the entrance.

b. During occupancy, the atmosphere in the enclosure shall be refreshed every fifteen (15) minutes by the induction of 600 to 900 cfm of outside air for approximately one (1) minute.

c. There shall be no regular ventilation during unoccupied periods to enable efficient operation of the environmental system and to avoid needless wear-and-tear on the ventilation blower.

An atmospheric monitor shall be provided with the ECP to continuously sample the air with the enclosure. The monitor functions and remote alarms are described in a following section of this specification.

An immediate visual indication of a safe or hazardous vault atmosphere shall be provided by green and red pilot lights visible while above ground through the open entrance hatch. Audible alarms shall supplement the visual indication during potentially hazardous conditions. Safe conditions shall be indicated with a continuous green light. The five (5) minute air purge operation shall be indicated by a flashing-red light. Unsafe conditions shall be indicated with a continuous red light and audible alarm horn. In addition, an unsafe atmospheric condition shall activate the ventilation system to purge the vault chamber and initiate a remote alarm.

A sump pump rated at 1300 gph @ 5 feet head pressure and 600 gph @ 15 feet head pressure shall be installed approximately 8 inches below floor level. The pump shall be capable of drawing down to 3/16 inch water depth. It shall be controlled through the ECP. Float switches shall start the pump at approximately 1.5 inch water depth and stop the pump at approximately 0.5 inch water depth. Pump run time longer than 6 minutes shall initiate a remote alarm. The pump shall be piped to the exterior in a manner that shall not permit an electrical ground through the piping to the steel exterior of the vault. This discharge piping shall utilize threaded connections and contain two (2) automatic back-flow preventer valves within 12 inches of the pump. A pipe union shall be installed near the pump to facilitate removal for inspection or repair.

Vault Security/Monitor Alarms

Alarm indications shall be wired to an Alarm Terminal Block (ATB) so the existence of any alarm condition can be transmitted to a remote location. The alarm indications shall be given as a dry normally open contact closure (or Form C contacts when possible). No indication of remote (silent), dry contact, alarms need be provided at the vault; however, hazardous alarm conditions shall provide audible or visual alarm indications at the vault when occupied for personnel safety. No audible alarm should be heard when the vault is unoccupied; however, the remote alarm shall continue to function. Upon opening the entry hatch, any preexisting hazardous condition shall trigger the local alarms immediately upon opening of the entrance hatch.

Design-Builder shall provide all necessary equipment and wiring to connect the above alarms to the Administrative, Operations, Maintenance facilities of the SONET system so as to provide a functioning alarm system from the Communication Hub to the TSMC at Dayton.

Intrusion Alarm
A remote alarm indication shall be activated immediately upon opening the entrance hatch. Closing the entrance hatch shall restore the alarm switch to its normal position.

Water Detection Alarm
A water sensor located approximately 8 inches below floor level shall signal a remote alarm condition if water is present at the sensor. The sensor shall detect as little as 1/16 inch water film depth. This shall provide an early alarm for a cable duct leak or other water leakage that could damage the system equipment and the vault interior if the condition is not corrected.

Sump Pump Run Alarm
The ECP shall monitor the sump pump operation and provide a delayed, remote alarm indication if the pump has started and has run for over 6 minutes.

High Water Alarm
A float switch shall monitor water level and initiate a final water alarm in the event of a rise in water level beyond the capability of the sump pump. This alarm point shall occur at least 4 inches below the floor level were equipment is installed.

Explosive Atmosphere Alarm
An alarm indication shall be activated by an unsafe condition reported by the Atmospheric Monitor explosive gas sensing element. Explosive gas (10% or more LEL lower explosive level of Methane) detection shall: (1) initiate a remote alarm, (2) give a steady red pilot light indication in the entrance way, (3) activate the fresh air blower, and (4) sound a local alarm. The remote alarm shall provide an immediate remote alarm indication, even though the fresh air blower may clear the explosive condition. Additionally, the local audible alarm and red pilot light shall be activated for immediate indication of a hazardous condition. It shall not be possible to silence the local audible alarm at the vault, and the red pilot light shall remain lighted until the condition clears. Once the Atmospheric Monitor reports a safe condition, these alarms and indications shall be automatically deactivated.

Toxic Atmosphere Alarm
An alarm indication shall be activated by an unsafe condition reported by the Atmospheric Monitor toxic gas sensing element. Toxic gas (100 parts/million Carbon Monoxide) detection shall: (1) initiate a delayed, remote alarm, (2) give an immediate steady red pilot light indication in the entrance way, (3) activate the fresh air blower, and (4) sound a local alarm. The delayed remote alarm shall provide an opportunity for the fresh air blower to clear the toxic condition before reporting the condition remotely. Locally, however, the audible alarm and red pilot light shall be activated for immediate indication of a hazardous condition. It shall not be possible to silence the local audible alarm at the vault and the red pilot light shall remain lighted until the condition clears. Once the Atmospheric Monitor reports a safe condition, these alarms and indications shall be automatically deactivated.

Smoke Alarm
The atmospheric monitor shall incorporate a photoelectric smoke detector. Upon detection the system shall: (1) initiate a remote alarm, (2) give a steady red pilot light indication in the entrance way, (3) deactivate and lock out the fresh air blower, and (4) sound a local alarm. The audible alarm and red pilot light shall be activated for immediate indication of a hazardous condition. It shall not be possible to silence the local audible alarm at the vault and the red pivot light shall remain lighted until the condition clears. Once the Atmospheric Monitor reports a safe condition, these alarms and indications shall be automatically deactivated.

Atmospheric Monitor Failure Alarm
The atmospheric monitor shall initiate a remote alarm condition upon: (1) failure of any gas sensor, and (2) failure of AC and DC backup power sources.

High Humidity Alarm
An alarm humidistat shall be provided at the ECP to give a remote alarm indication if the relative humidity (RH) reaches a preset level. The High Humidity alarm point shall be adjustable between 20% and 80% RH.

High Temperature Alarm
An alarm thermostat shall be provided at the ECP to give a remote alarm indication if the vault interior temperature exceeds a preset level. The High Temperature alarm point shall be selectable in a range from 55 to 175 degrees Fahrenheit.

Vent Blower Alarm
A lack of ventilation air flow (when air flow is required) shall initiate a remote alarm indication. Additionally, if the vault is occupied during the failure, a local alarm horn shall sound and the red pilot light, visible in the entrance-way, shall be lighted. The ventilation audible alarm shall be a different tone from the atmospheric audible alarm. If the vault is unoccupied no local alarm shall sound. If the entry hatch, is opened during a pre-existing alarm condition, the local alarm shall immediately notify personnel of the impending danger. The alarm horn shall be capable of being silenced at the ECP by maintenance personnel, but the red light indication and the remote alarm shall continue until the trouble has been resolved. Once the trouble condition has been cleared, the monitoring function shall be automatically reset. The silencing function shall be self-restoring so it is unnecessary for personnel to reset the system manually.

Power Failure Alarm
An interruption of the Utility Service shall cause a remote alarm indication. Restoration of power shall silence the alarm. Both legs of the 120/240V single phase service are monitored so a failure of either one or both legs shall trigger the alarm condition.

Uninterruptable Power Supply (UPS)
The Design-Builder shall furnish and install an Uninterruptable Power Supply (UPS) inside the communication hub SCEV. The UPS shall provide complete power protection for all communication system components, sump pump and the air circulation system during power outages and "brown-outs." The UPS shall provide a minimum of 37 minutes of power support at rated capacity.

The UPS shall satisfy all of the parameters as specified below:

The UPS shall be UL 1449 listed, and shall pass ANSI/IEEE C62.41 Categories A and B for Lighting and Surge Protection.

The Spike Attenuation shall be 2000 to 1. The unit shall have complete Galvanic Isolation from the line, and the output neutral shall be bonded to the ground. The noise (RF) Isolation shall be 120 dB in common-mode, and 60 dB in normal-mode.

The line input shall be from 96 VAC to 138 VAC. The output voltage shall be 120 VAC with +/-3% regulation. The output waveform shall be a pure sine-wave with less than 5% Total Harmonic Distortion (THD). The UPS shall employ a Ferro resonant transformer for output overload, and current limiting protection.

The UPS shall have a capacity of at least 3.1 kVA with at least 37 minutes of full rated capacity load.

The on-line efficiency of the unit shall be between 85% to 91%. The on-line audible noise shall be between 41 dB and 51 dB.

The foot-print of the UPS shall not be greater than 16 inches W x 23 inches D.

The UPS shall tolerate an operating environment of +32°F to +104°F, and 0 to 95% relative humidity (non-condensing).

The UPS shall be Best Power Technology 3.1 kVA unit.

1. Equipment Model Numbers:

UPS	FE3.1 kVA
Extended Runtime Option	ERT3.1B

2. Manufacturer:

   Best Power Technology, Inc.
   P.O. Box 280
   Necedah, WI 54646
   Telephone: (800) 356-5794

Construction Requirements

Section 8-20.3 is supplemented with the following:

The Design-Builder shall provide shop drawings of the SCEV's electrical system, vault construction, corrosion protection system, and all component locations and connections. The Design-Builder shall also provide for interfacing of SCEV alarm contacts with SONET equipment.

Site Preparation

Care shall be exercised in site preparation, in positioning the vault on the selected site, and in finish grading to avoid any possibility of any flood

condition, which would submerge the entranceway. The vault shall be placed on a 6 inch sand drainage blanket. The structure excavation Class B, shoring or extra excavation, sand drainage blanket, backfill and compaction shall be in accordance with Section 2-09.

Installation
The vault chamber shall be shipped in one piece to the installation site and installed into the excavation without the need for personnel to be in the excavation. Multiple-piece vault chambers, requiring assembly in the excavation will not be accepted. Additionally, the one-piece vault chamber shall be structurally and physically suitable for the installation of the system equipment prior to final shipment to the job site. Installation of the system equipment shall take place at the vault manufacturer's facility.

Such anchoring shall be accomplished without the necessity for personnel to enter the excavation after vault installation. An anchoring system shall be proposed by the Design-Builder for approval by WSDOT prior to installation.

The steel vault shall not be used as a grounding point for any installed electrical or electronic equipment.

A separate, internal ground point shall be provided for the vault electrical system and WSDOT's system equipment and shall be labeled as "System Ground." Earth grounding for this point shall be accomplished with two external 5/8 inch by 8 foot Copper Ground Rods and ground wires provided by the vault installer.

Finished Grade
The entranceway shall extend above the vault enclosure to allow for an earth cover over the vault chamber, as shown in the Plans, and for sufficient room above the finished surface for clearance of intake and discharge air openings.

Vault Electrical System
The enclosure shall be equipped for 120/240 volt, single-phase, 60 Hz, 100 AMP underground utility service from a remote meter pedestal. All conduits shall enter below grade. Two inch diameter NPT threaded couplings shall be provided for all conduit entries. A dielectric connection shall be provided at the vault to insure that no grounding is provided by the conduits. The electrical service conductors shall include ground conductor(s).

The distribution system shall be rated 100 AMP for both utility and auxiliary sources. The utility service shall connect to a 100 AMP main breaker which shall be an integral component of a manual transfer panel (MTP). In the NORMAL position, the manual transfer panel (MTP) shall connect the utility service through to a 125 AMP distribution panel (DP) that contains all branch circuit (breaker) protection.

Warranty
In addition to the requirements of Section 1-05.10 **Guarantees**, the Design-Builder shall provide a one-year (minimum) manufacturer's warranty for major components of the communications hub steel controlled environment vault system. These warranties shall be written by the manufacturer or authorized repair agent of said equipment and shall include parts and labor and return freight or shipping. The warranty shall name Washington State DOT Northwest Region Signal Maintenance Superintendent as the equipment owner. The

warranty shall cover defects in material and workmanship under normal use. The State will be responsible for items damaged due to accidents, acts of God, misuse, negligence by the State, or by a third party. The following components shall be provided with a warranty:

Vault environmental system
Vault security/monitor alarms
Uninterruptible power supply (UPS)

The Design-Builder shall coordinate the warranty period with the manufacturer, or authorized repair agent of said equipment, to begin upon acceptance of the system. Acceptance of the system is defined as starting on the physical completion date of the contract or, if relief of responsibility is to be granted in accordance with Section 1-07.13(2), on the date WSDOT relieves the Design-Builder from responsibility for the completed system.

The Design-Builder shall provide WSDOT with a written copy of all manufacturers' warranties for the communications hub steel controlled environment vault system. The warranty document shall denote that the warranty period begins upon acceptance of the system and not on product delivery.